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Part I: Systematics of Some Gulfian Trachyleberids From Texas and Arkansas. Part II: Ostracode Biostratigraphy in Some Austinian-Tayloran Rocks.

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A Dissertation

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by
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ABSTRACT PART I

The mid-Late Cretaceous representatives of the ostracode family Trachyleberididae in the Western Gulf Coast area are herein systematically revised in the light of recent taxonomic discoveries. Possible lineages are discussed for several species and genera. Twenty-six Austinian and Tayloran (approximately equivalent to the Senonian) species are listed or described. One genus, _Diversipellis_, with _D. bicornis_ as the type species, one species, _Pterygocythereis ingens_, and two subspecies, _Isocythereis hadraina orchama_ and _Diversipellis bicornis rectangula_, are new. A new name, _Costa redunca_, is proposed for one species, _Cythereis pidgeoni_ (Berry), Paulson _not_ Berry.

ABSTRACT PART II

Analysis of ostracode faunules from the upper formations of the Austin Group and lower formations of the Taylor Group in central and north-central Texas reveals that the sequence is divisible into two zones. The lower zone, herein named the _Pterygocythereis burdittensis_ zone, is an assemblage-zone, but with the boundaries defined on the ranges of individual species or groups of species. The superjacent _Bradleya plummeri_ zone is a range-zone with its boundaries defined primarily by the range of the widespread _B. plummeri_. Ostracode occurrence data from northeast Texas and Arkansas show that the zones can be carried into these areas.

Results of the zonation indicate that the Dessau Chalk, Burditt Chalk Marl and Big House Chalk of central Texas are correlative with the "Upper Chalk" and lower part of the "Lower Taylor" Marl in the Dallas, Texas, area, the Brownstown Marl, Gober Chalk and lower part of the "Lower Taylor" in northeast Texas and with the Brownstown of Arkansas. The "Lower Taylor" and lower part of the Pecan Gap Chalk of central Texas are correlative with the upper "Lower Taylor," Wolfe City Sand and Pecan Gap in north-central and northeast Texas and with the lower half of the Ozan Formation of Arkansas. The Austin-Taylor disconformity in the Travis County area correlates with the disconformity which separates the Brownstown and Ozan in Arkansas and divides the "Lower Taylor" in northeast Texas. This disconformity is a younger feature than the locally important disconformity between the Austin and "Lower Taylor" in the Waco, Texas, area.

The sedimentary pattern in the Austinian was one of calcareous deposition in the southwestern areas with arenaceous or argillaceous sedimentation to the northeast and argillaceous-calcareous deposits between. The dominant source of clastic materisl is believed to have been that part of the Ouachita System in Louisiana and Arkansas.

During the time of the Bradleya plummeri zone the sedimentary pattern was the reverse of the Austinian as argillaceous sedimentation predominated in the southwestern areas while calcareous deposits were laid down in the northeast. The site of maximum deposition shifted southwestward and the Cordilleran region apparently supplied the bulk of clastic materials with local areas contributing clastics at times.

PART I

INTRODUCTION

Deposits of mid-Late Cretaceous age, the Austinian and Tayloran stages (Murray, 1961), crop out in a sinuous belt across Texas and into southwestern Arkansas. The Austin Group and lower part of the Taylor Group in central and north-central Texas are, in general, fossiliferous with respect to ostracodes. The same is true of equivalent lithostratigraphic units in northeast Texas (Alexander, 1929; Paulson, 1960 ms, 1964) and southwestern Arkansas (Israelsky, 1929; Thorsen, 1959 ms; Collins, 1960 ms).

A general history of Cretaceous ostracode study was presented by Howe (1956) and a comprehensive compilation of described species by Howe and Laurencich (1958) followed. These works and other bibliographic sources show that ostracode studies on the Upper Cretaceous, particularly the Senonian and its equivalents, have lagged behind those on the Lower Cretaceous. The abundance of chalk rock in the Upper Cretaceous has much to do with this lag, for, in general, this rock type does not yield its microfauna easily.

The study of Cretaceous ostracodes in the Coastal Plain of North America began with the work of Berry (1925), Vanderpool (1928) and Israelsky (1929); the inclusive work by Alexander (1929) followed. Alexander hoped his 1929 northern Texas study would induce paleontologists to study further the Cretaceous ostracodes of the Coastal Plain and to make use of them in biostratigraphy. However, during the next ten years, with the principal exception of Jennings (1936), nearly all the papers dealing with Cretaceous ostracodes of the Coastal Plain were authored by Alexander. In recent years important papers have been contributed by Swain (1948, 1952), Schmidt (1948), Hill (1954), Skinner (1956), Butler and Jones (1957), Brown (1957, 1958) and Paulson (1964).

These later papers, with the exception of Hill (1954), have been primarily stratigraphic or biostratigraphic, rather than systematic, though several important taxonomic contributions were made. Thus the ostracodes of some families are in need of systematic revision in the light of recent taxonomic research. This is particularly true of those species which are referable to the family Trachyleberididae. The present paper is an endeavor to revise systematically the trachyleberid species of the Austinian and early Tayloran of central and northeast Texas and southwestern Arkansas.

The localities listed below were chosen from a much larger number which were used in a biostratigraphic analysis (Hazel, 1964), more detailed occurrence and abundance data on the species listed or described herein can be found in that paper.

LOCALITIES

A-3.-- Dessau Chalk. Gully along east side of Dessau Road between Braker Lane and an east flowing tributary to Walnut Creek, northeast of Austin, Travis County, Texas. The sample was taken from a soft, marly chalk just above a zone of abundant Gryphaea aucella and just below a hard chalk ledge that causes a small waterfall. Collector: L. deA. Gimbrede

B-10.-- Big House Chalk. North side of third gully upstream from U. S. highway 290 crossing of Little Walnut Creek, just northeast of Austin, Travis County, Texas. The sample was taken from a marl below a one-foot chalk bed at the top of Big House. Collector: J. E. Hazel

C-1.-- Big House Chalk. Left bank of Little Walnut Creek, 40 feet upstream from old Manor road crossing in Travis County, Texas, just northeast of Austin. The sample was taken from a six inch marl bed above a two foot chalk at base of the section. Collector: L. G. Nichols

C-2.-- Big House Chalk. Left bank of Little Walnut Creek just north of first west flowing tributary, 50 yards downstream from old Manor road crossing. The sample was taken from a soft marl six feet above the base of outcrop and seven feet below the "Lower Taylor" contact. Collector: J. E. Hazel

C-7.-- "Lower Taylor" Marl. In left bank of tributary just across from C-2. The sample was taken from a brown, weathered clay six feet above the disconformable Big House contact. Collector: J. E. Hazel

C-9.-- "Lower Taylor" Marl. Left bank of Little Walnut Creek 200 yards downstream from old Manor road crossing. The sample was taken from a clay 16 feet above water level. Collector: L. deA. Gimbrede

C-10.-- "Lower Taylor" Marl. Left bank of Little Walnut Creek 200 yards downstream from old Manor road crossing. The sample was taken from a clay at the top of the bluff. Collector: L. deA. Gimbrede

D-1.-- "Lower Taylor" Marl. Just west of small roadside park on U. S. highway 290, 1.8 miles east of bridge over Little Walnut Creek, northeast of Austin, Travis County, Texas. The sample was taken from a marl a few feet lower than the base of Texas Bureau Economic Geology locality 226-T-50. Collector: L. deA. Gimbrede

D-2.-- "Lower Taylor" Marl. Roadcut on U. S. highway 290, 0.1 mile east of Walnut Creek crossing and just west of MKT railroad crossing northeast of Austin, Travis County, Texas, (Texas Bureau locality 266-T-50). The sample was taken from an upper marly bed near the east end of the 20 foot exposure. Collector: L. deA. Gimbrede

D-3.-- "Lower Taylor" Marl.- One-half mile east of MKT railroad crossing of U. S. highway 290 northeast of Austin, Travis County, Texas. The sample was taken from the chalky clay beds in the upper part of a 12 foot exposure (Texas Bureau Economic Geology locality 226-T-40). Collector: L. deA. Gimbrede

E-1.-- Big House Chalk. Roadcut on county road uphill (west) of the road crossing of Walnut Creek, just west of Sprinkle Community northeast of Austin, Travis County, Texas. The sample was taken from a marl interbed at the base of the 17 foot exposure. Collector: J. E. Hazel

E-3.-- Big House Chalk. Twelve feet above E-1 in a marl. Collector: J. E. Hazel

G-8.-- Wolfe City Sand. Creek bank where northwest flowing tributary to Pond Creek crosses under a graded road 1.3 miles southeast of intersection with farm road 935 and 4.4 miles south of Durango, Falls County, Texas. Collector: L. deA. Gimbrede

G-9.-- Wolfe City Sand. Roadside bank on northeast side of graded road 0.4 mile southeast of G-8 and 0.15 mile northwest of a road junction. Collector: L. deA. Gimbrede

H-1.-- Big House Chalk. Chalk bluff on south side of San Gabriel River, one mile east of Jonah, Williamson County, Texas. The sample was taken from a marly chalk at the base of the bluff, 20 feet below the Austin-Taylor contact. Collector: L. deA. Gimbrede

M-1.-- Lower Austin (pre-Dessau). Ninety foot exposure just upstream from where the Pleasant Hill-Bluff Springs road crosses northernmost branch of a tributary to Onion Creek in southern Travis County, Texas. The sample was taken from a marl break just above water level on the upstream side of a small normal fault 250 yards upstream. Collector: J. E. Hazel

M-2.-- Lower Austin. Same locality as M-1. The sample was taken from a marl break below a six foot chalk and above a five foot chalk, 25 feet above M-1. Collector: L. deA. Gimbrede

O-1.-- "Upper Chalk." Exposure 1.6 miles east of Garland, Dallas County, Texas courthouse, fifty yards downstream from the crossing of a tributary of Rowlett Creek by state highway 7. The sample was taken from a blue, knobby marl below the uppermost chalk in the left bank. Collector: J. E. Hazel

P-1.-- "Upper Chalk." Holford Road crossing of Spring Creek in northern Dallas County, Texas. The sample was taken from a blue, knobby marl five feet northwest of the bridge in the right bank. Collector: J. E. Hazel

R-1.-- "Upper Chalk." Halfway between the crossings of Apollo and Brand Roads by Spring Creek. The sample was taken from a soft marl in the right bank below a chalk with _Gryphaea_ _aucella_ and large _Inoceramus_ sp. Collector: J. E. Hazel

T-1.-- "Middle Marl." S&S Aggregate Company quarry in southern Dallas County, Texas, 2.3 miles southeast of Loop 12-U. S. 75 and Interstate 45 intersection and 1000 yards west of the highway. The sample was taken from a marl bed with many large _Inoceramus_ sp. on the upper level of the quarry. Collector: J. E. Hazel

T-3.-- "Middle Marl." Roadcut on U. S. 75-Interstate 45 on south edge of Trinity River floodplain, 2.3 miles southeast of the Loop 12 intersection in southern Dallas County, Texas. The sample was taken from a chalky marl at the northwestern end of the outcrop six feet above road level. Collector: J. E. Hazel

W-1.-- "Upper Chalk." Exposure 0.5 mile northwest of Wilmer, southern Dallas County, Texas, on left bank of Cottonwood Creek 25 yards east of old U. S. 75 crossing. The sample was taken from a marl eight feet above water level and below a two foot chalk bed. Collector: J. E. Hazel

2A-1.-- "Lower Taylor" Marl. Gully 100 yards east of state highway 24, 0.9 mile north of Lake Creek, Delta County, Texas. The sample was taken near the crest of the hill. Collector: L. G. Nichols

2B-1.-- Buckrange Sand member of Ozan Formation. NE¼, NW¼, Sec. 10, T11S, R29W, Sevier County, Arkansas, southwestern end of Ozan outlier on Brownstown-Ben Lomond road. This is stop 3 (pp. 209-211) of

Shreveport Geol. Soc. 14th Annual Field Trip (1939). Collector: B. C. Craft

2C-1.-- Brownstown Marl. NE¼, NW¼, NW¼, Sec. 10, T11S, R29W, Sevier County, Arkansas, roadcut on south side of Ben Lomond-Brownstown road, 0.1 mile west of Gravelly Hill Church. Collector: B. C. Craft

2D-1.-- Brownstown Marl. Center, NW¼, Sec. 5, T11S, R29W, 0.5 mile east of Wilson Creek on road to Ben Lomond from U. S. 71, Sevier County, Arkansas. Collector: H. V. Howe

2E-1.-- Brownstown Marl. SW¼, SE¼, Sec. 5, T11S, R29W, ditch on north side of road, 0.5 mile south of Ben Lomond, Sevier County, Arkansas. This is stop 2 (p. 209) of Shreveport Geol. Soc. 14th Annual Field Trip (1939). Collector: B. C. Craft

2F-1.-- Lower Austin. Bluff on the left bank of Williamson Creek 0.4 mile upstream from where the creek is crossed by state road 275 (South Congress Avenue), in Travis County, Texas, just south of Austin. The sample was taken from a marl break in a chalk sequence nine feet above a bed at water level which contains <u>Exogyra</u> <u>laeviuscula</u> and <u>Eutrephoceras</u> sp. Collector: J. E. Hazel

2G-1.-- Brownstown Marl. Roadside gully 1.35 miles northwest of Brownstown, Sevier County, Arkansas. Collector: H. V. Howe

2H-1.-- Dessau Chalk. Gully of a southwestward flowing intermittent stream which is a tributary to the Leon River; outcrop is 1.0 miles north of Hartricks Bluff on the Leon River, 4.4 miles southeast of U. S. 81 and State Farm Road 1741 intersection in Belton and 150 feet south of a pasture road (Bell County, Texas). The sample was taken from a marl at the top of the gully. Collector: L. deA. Gimbrede

2I-1.-- Dessau Chalk. Chalk bluff on east bank of Brazos River 6.2 miles upstream from where White Rock Creek enters the Brazos and 1.0 miles downstream from where Elm Creek enters the Brazos. The sample was taken from a marl break below a prominent chalk 40 feet above water level. Collector: L. deA. Gímbrede

SPECIES

SAMPLES	Bradleya crassicarinata	Bradleya plummeri	Bradleya rugosissima	Costa redunca	"Cythereis" caudata	Cythereis dallasensis	"Cythereis" hannai	Diversipellis alexanderi	Diversipellis bicornis bicornis	Diversipellis bicornis rectangula	Diversipellis niobrarensis	Diversipellis taylorensis	Henryhowella spoori	Isocythereis aff. I. austinensis	Isocythereis austinensis	Isocythereis hadraina hadraina	Isocythereis hadraina orchama	Phacorhabdotus simplex	Pterygocythereis burdittensis	Pterygocythereis compressa	Pterygocythereis ingens	Pterygocythereis ponderosana	Pterygocythereis tokiana	Trachyleberididae sp.	Trachyleberidea anocula	Veenia bonhamensis	Veenia ozanana	Veenia gapensis
A-3						x	x		x							x											x	
B-10						x			x							x			x				x	x				
C-1					x	x			x							x		x	x				x	x				
C-2						x	x	x	x							x			x			x	x	x				
C-7	x		x						x			x				x											x	
C-9		x					x					x															x	
C-10		x	x				x					x															x	
D-1	x	x	x				x					x															x	
D-2	x	x	x				x					x								x							x	
D-3		x				x	x																				x	
E-1						x	x		x							x		x	x		x			x			x	
E-3					x	x			x							x		x	x									
G-8	x	x	x									x	x														x	
G-9	x	x	x																								x	
G-10		x																										x
H-1						x			x										x		x							
M-1										x																		
M-2										x													x			x		
O-1					x	x			x		x					x		x					x		x		x	
P-1					x	x	x		x						x	x		x					x				x	
R-1					x				x							x		x					x				x	
T-1					x	x			x							x	x	x					x					
T-3					x	x				x					x		x										x	
W-1					x	x			x		x					x		x					x		x		x	
2A-1														x														
2B-1				x		x	x		x			x	x			x				x			x				x	
2C-1						x																					x	x
2D-1							x		x											x								
2E-1									x				x							x			x				x	
2F-1										x																		
2G-1				x					x				x														x	x
2H-1						x			x						x		x						x				x	
2I-1											x																	

Text figure 1.- Trachyleberididae occurrences at the described localities.

SYSTEMATIC DESCRIPTIONS

Subclass OSTRACODA Latreille, 1802

Order PODOCOPIDA G. W. Muller, 1894

Superfamily CYTHERA⁻ΞA Baird, 1850

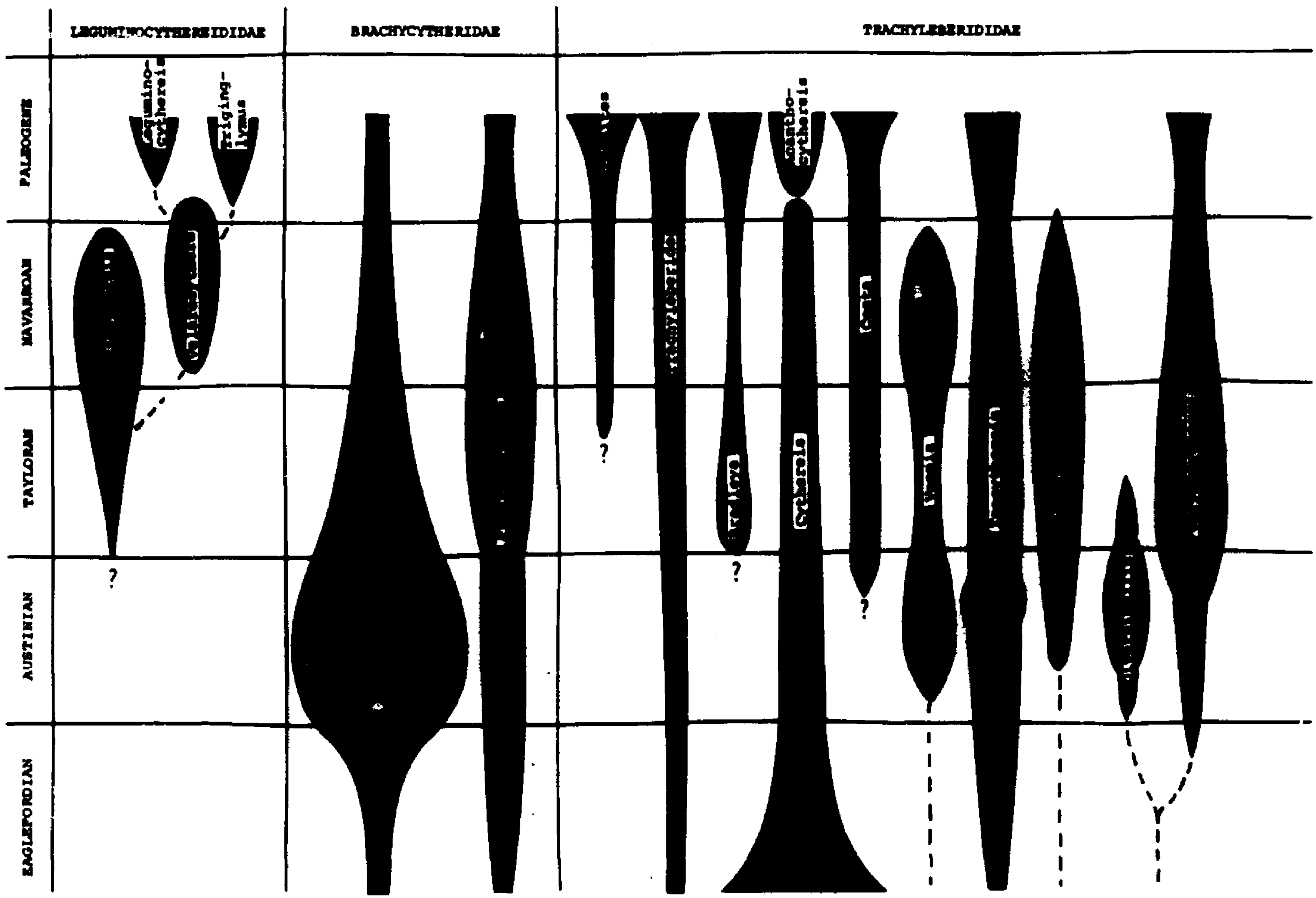
Family TRACHYLEBERIDIDAE Sylvester-Bradley, 1948

Discussion.- Porkorný in 1957 and again in 1958 stressed that the family Trachyleberididae of Sylvester-Bradley is an artifical taxon based primarily on the amphidont hinge. Therefore, in his 1958 classification, Pokorný placed the trachyleberids in the subfamily Cytherinae Baird, justifying this by stating that the Cytherinae have reached a stable size in zoologic work and Recent trachyleberids are generally placed in the subfamily by zoologists (ibid., p. 256).

Neale (1959) recognized the family as zoologically distinct and in 1962 used it as a subfamily of the Cytheridae, as Pokorný (1958, p. 259) had reluctantly suggested. The writer agrees with Pokorný that the family as now used has become rather artificial, but also with Neale that it, as based on Trachyleberis, can form a valid evolutionary family. However, more phylogenetic studies will be necessary before the family can be stabilized on this basis.

Text figure 2 shows the inferred ranges and possible lineages of the described trachyleberid genera of the Coastal Plain Upper Cretaceous together with the genera of two closely related families, Brachycytheridae and Leguminocythereididae. The width of the balloons is roughly proportional to the number of species in the genus. It is apparent that as Cythereis s. s. wanes in the Upper Cretaceous several trachyleberid genera appear and expand. However, the greatest expansion is undergone

Text Figure 2.- Inferred ranges and possible lineages of the described trachyleberid genera of the Coastal Plain Upper Cretaceous together with the genera of two closely related families.



Text Figure 2

by the genus Brachcythere of the Brachycytheridae. In turn, in the later Tayloran and Navarroan, Brachycythere wanes and other genera, particularly those of the family Leguminocythereididae, expand.

GENUS CYTHEREIS JONES, 1849

Discussion.- At present there are nearly 150 species of Cretaceous ostracodes carried in the genus Cythereis. Many of these were so placed, or were left in the taxon once placed there, because of taxonomic convenience and do not really belong in the genus at all. Nearly all the previously described species mentioned in this paper were at one time carried in Cythereis, but only one positively belongs there.

The genus, with such forms as Cythereis senckenbergi Triebel, C. burlesonensis Alexander and C. pustulosissima Alexander as typical representatives, is common in the lower and middle parts of the Cretaceous, but wanes in the Eaglefordian and its approximate European equivalent, the Turonian, and, in terms of numbers of species, is not common above these stages. As this important taxon underwent reduction other taxa expanded and new ones appeared (text fig. 2).

As Sylvester-Bradley (1948) proposed, the genus appears to have been derived from Oligocythereis. In turn, it is the progenitor of several Cretaceous and Tertiary genera.

Cythereis dallasensis ALEXANDER

Plate 1, figures 16, 17

Cythereis dallasensis ALEXANDER, 1929, Texas Univ. Bull. 2907, pl. 8, figs. 8,9.- HOWE and LAURENCICH, 1958, Intro. to Study Cretaceous Ostracoda, p. 192,193, 2 fig.- PAULSON, 1964, Jour. Pal., vol. 37 (in press).

Cythereis ornatissima (Reuss).- ALEXANDER, 1933, Jour. Pal., vol. 7, p. 210, pl. 25, fig. 18; pl. 26, figs. 11a, b; pl. 27, figs. 16a,b.

Diagnosis.- Cythereis with reduced ribs, reticulate, spinose surface; prominent posterodorsal and posteroventral spinose tubercles; large eye tubercle.

Dimensions.- Range of length 0.72-0.82 mm., mean 0.77; height 0.38-0.44, mean 0.41; width 0.32-0.38, mean 0.35.

Discussion.- This species appears to be descended from ostracodes of the Cythereis pustulosissima Alexander type and very probably is part of the ancestral stock of several Tertiary species for which the genus Acanthocythereis has recently been proposed (Howe, 1963). Evolutionary tendencies within this lineage are reduction of the strong longitudinal ribs of Cythereis s. s. to almost imperceptible rows of spines, reduction in size of the muscle node, shift of the principal area of carapace inflation from ventrolateral to medial and loss of crenulation of the terminal hinge elements.

Occurrence.- The species is very common in the Austin Group and its northeast Texas equivalents, but rare in the Austin equivalent of Arkansas. It ranges into lower part of the Tayloran.

"Cythereis" caudata BUTLER and JONES

Plate 1, figure 10

Cythereis caudata BUTLER and JONES, 1957, Louisiana Geol. Survey Bull. 32, p. 34, pl. 4, fig. 8.- HOWE and LAURENCICH, 1958, Intro. to Study Cretaceous Ostracoda, p. 188, 1 fig.

Cythereis faujasi Veen.- PAULSON, 1964, Jour. Pal., vol. 37 (in press).

Diagnosis.- A trachyleberid species, genus uncertain, with prominent knobs at posterior ends of ventral and dorsal ribs; frilled anterior (usually not preserved); no median rib.

Dimensions.- Range of length 0.44-0.50 mm., mean 0.47; height 0.25-0.30, mean 0.27.

Discussion.- This long-ranging species is very similar to "Cythereis" faujasi Veen, but, with other differences, it is considerably smaller. Neither species appears to belong to Cythereis s. s., and, after further study a new genus may be required for them.

Occurrence.- The species ranges from the upper part of the lower Austinian in central and northeast Texas to the Saratoga Chalk equivalent of Louisiana, usually considered Navarroan (Butler and Jones, 1957). It is not common in any of the writer's samples.

"Cythereis" hannai ISRAELSKY

Plate 1, figures 21, 26

Cythereis hannai ISRAELSKY, 1929, Arkansas Geol. Survey Bull. 2, p. 16, pl. 4A, figs. 1a-c.- HOWE and LAURENCICH, 1958, Intro. to Study Cretaceous Ostracoda, p. 200, 1. fig.- PAULSON, 1964, Jour. Pal., vol. 37 (in press).

Diagnosis.- A trachyleberid species, genus uncertain, with weakly developed ribs; posteroventral and posterodorsal protuberances on females, but only posterodorsal protuberance on males; reticulate to pitted surface (well-preserved specimens hispid).

Dimensions.- Range of length 0.40-0.59 mm., mean of females 0.41, mean of males 0.53; height 0.21-0.27, mean of females 0.22, mean of males 0.24; width (females only) 0.17-0.21, mean 0.19.

Discussion.- This species shows very strong sexual dimorphism. The inferred males are more elongate and do not possess the posteroventral protuberance of the females. "Cythereis" hannai resembles somewhat species of the genus Trachyleberidea. It is not as compressed as most species of Trachyleberidea, but it possesses the posterocentral tubercle, though small, typical of that genus. The inferred females of this species usually carry the posterodorsal and posteroventral protuberances common in Trachyleberidea, but the males do not. The species also resembles a group of species typified by "Cythereis" cancellosa Alexander and may be intermediate between Trachyleberidea and the cancellosa group.

Occurrence.- "C." hannai is common in the Austin of central Texas but is much more abundant in the Brownstown Marl of Arkansas and northeast Texas. It is rare in lower Tayloran deposits.

GENUS TRACHYLEBERIDEA BOWEN, 1953

Discussion.- In a recent paper Haskins (1963) attempted to clarify the confusion concerning the type species of Trachyleberidea, Cythereis prestwichiana Jones and Sherborn, by redescribing it and C. aranea Jones and Sherborn. He verified Keij's (1957) observation that Bowen (1953) had confused the two species when he established the genus. Both Haskins and Keij considered the two species congeneric, a conclusion with which the writer cannot agree.

After examination of specimens of C. prestwichiana from the London Clay (sample obtained through the courtesy of Mr. Dennis Curry), the writer concludes that the several species of the aranea type probably can be cogently placed in the genus Isocythereis Triebel, whereas Trachyleberidea as based on Cythereis prestwichiana forms a second easily recognizable group of species.

Tertiary species assignable to Trachyleberidea include, besides the type, Cythereis howei Gooch, C. blanpiedi Howe and Law and C. goochi Swain. Cretaceous species include Cythere acutiloba Marsson, Cythereis anocula Paulson and, the oldest known species, C. carpenterae Alexander. These species all have a reticulate surface and in well-preserved specimens "teeth" are sometimes present in the reticules. Posterodorsal and posteroventral protuberances are present at the ends of the dorsal and ventral ribs. An extremely short median rib is sometimes present, but in most species a posterocentral node is present instead. All species have a distinctly pointed posterior.

Trachyleberidea anocula (PAULSON)

Plate 1, figures 3, 4

Cythereis anocula PAULSON, 1964, Jour. Pal., vol. 37 (in press)

Diagnosis.- Very compressed Trachyleberidea with the muscle node and posterocentral node weakly developed.

Dimensions.- Range of length 0.61-0.65 mm., mean 0.62; length 0.32-0.36, mean 0.33; width (two carapaces) 0.20.

Discussion.- This very compressed species is quite close to Trachyleberidea acutiloba (Marsson) which is found in Senonian rocks of Europe. It differs from this species in being only a little more compressed.

Occurrence.- T. anocula is found in the upper Austin and very lowermost Taylor in central and north-central Texas. It is most common in the "Upper Chalk" of the Dallas area.

GENUS BRADLEYA HORNIBROOK

Discussion.- Three ostracode species which the writer has placed in the genus Bradleya occur in Tayloran rocks from Texas and Arkansas, Cythereis plummeri Israelsky, C. crassicarinata Paulson and C. rugosissima Alexander. Although they do not closely resemble Bradleya arata (Brady), the type species, they appear to be closely related to B. dictyon (Brady), which represents a group common in Recent seas and in the Tertiary. Recent and Tertiary Bradleya are described as possessing two frontal muscle scars anterior to a vertical row of four adductors. However, the species attributed to the genus herein possess a U- or J-shaped frontal scar. This may indicate that the Cretaceous species are not genetically related and the morphologic similarities are homeomorphous. Positive statements as to the exact relationship between these Upper Cretaceous species and the Tertiary and Recent species must await futher study, particularly of the faunas of intervening strata.

The genus has been reported from the Cretaceous by Reyment (1961, p. Q336) and by Apostolescu (1961), who used the taxon in a very broad sense.

Bradleya plummeri (ISRAELSKY)

Plate 1, figures 27-29

Cythereis plummeri ISRAELSKY, 1929, Arkansas Geol. Survey Bull. 2, p. 18, pl. 4A, figs. 2, 3.- HOWE and LAURENCICH, 1958, Intro. to Study Cretaceous Ostracoda, pp. 224, 225, 1 fig.- PAULSON, 1964, Jour. Pal., vol. 37, (in press)

Lectotype.- United States National Museum number 80,256B, a left valve, is hereby designated as the lectotype. This is cotype B of Israelsky (1929, pl. 4A, fig. 3).

Diagnosis.- Quadrate Bradleya with reticulate surface covered with blade spines.

Dimensions.- Range of length 0.78-0.86 mm., mean 0.82; height 0.44-0.46, mean 0.45; width 0.42-0.46, mean 0.43.

Discussion.- This common and distinctive species closely resembles the Tertiary and Recent members of the Bradleya dictyon group (compare figure 27, Plate 1 to plate XXIV of Brady, 1880).

Occurrence.- The species is a valuable biostratigraphic marker for the early Tayloran in Texas and Arkansas.

Bradleya rugosissima (ALEXANDER)

Plate 1, figure 30

Cythereis rugoissima ALEXANDER, 1929, Univ. Texas Bull. 2907, p. 101, figs. 13, 14.- HOWE and LAURENCICH, 1958, Intro. to Study Cretaceous Ostracoda, p. 231, 2 figs.- PAULSON, 1964, Jour. Pal., vol. 37 (in press)

Diagnosis.- Bradleya with very high, sharp anterior rim, dorsal rib, and ventral rib; short median ridge behind muscle node; reticulate surface.

Dimensions.- Range of length 0.70-0.80 mm., mean 0.75; height 0.37-0.42, mean 0.40; width 0.35-0.38, mean 0.36.

Occurrence.- This species is rather common, but not abundant, in the lower Tayloran in central Texas, rarer in northeast Texas and apparently does not occur in the Arkansas section.

Bradleya crassicarinata (PAULSON)

Plate 1, figures 15, 31

Cythereis crassicarinata PAULSON, 1964, Jour. Pal., vol. 37 (in press)

Diagnosis.- Bradleya with heavy rounded ribs and forked crossribs forming coarse reticular pattern; moderately strong sexual dimorphism.

Dimensions.- Range of length 0.70-0.84 mm., mean males 0.80, females 0.71; height 0.38-0.42, mean 0.40; width 0.36-0.42, mean 0.40.

Discussion.- This species appears to be the ancestor of the common Navarroan species "Cythereis" hazardi Israelsky. It differs from that species in possessing more robust ornamentation.

Occurrence.- The species is rather common in the lower Tayloran in central Texas, less so in northeast Texas and southwest Arkansas.

GENUS VEENIA BUTLER and JONES

Discussion.- Species of this genus are present in the North American Cretaceous from at least the lower Austinian into the upper Navarroan.

Butler and Jones (1957) suggest Veenia as the ancestor to Buntonia; however, the two genera are coeval in their early history as Buntonia apparently occurs in the Coniacian of Africa (Reyment, 1960, p. 169, also see pp. 190, 191) and Veenia in the Coniacian equivalent, the lower Austinian, of North America. Though there may be some relationship between the two, it is not successional and it is not clear.

Butler and Jones (1957) also suggest that Veenia is derived from Cythereis. This seems likely as V. ozanana resembles Cythereis of the C. subovata Alexander type and V. bonhamemsis bears a strong resemblance to Cythereis worthensis Alexander.

In addition to the two Veenia mentioned above, two other species from the Austinian and lower Tayloran of the Western Gulf have been placed in the genus, V. reticulata Paulson and V. striga Paulson. The former is, in the writer's opinion, a female of the species Henryhowella spoori (Israelsky). Veenia striga, along with some species attributed to that genus from Africa (Reyment, 1960) as well as the Gulf Cretaceous, V. arachoides (Berry) and V. sigma (Skinner), are problematic as to generic position. They resemble such species as Isobuntonia rimosa

Apostolescu, but not very much the type species of that genus. They also, particularly _arachoides_, resemble _Anticythereis_ (see van den Bold, 1963) except for the acuminate posterior.

Veenia _ozanana_ (ISRAELSKY)

Plate 1, fig. 14

Cythereis _ozanana_ ISRAELSKY, 1959, Arkansas Geol. Survey Bull. 2, p. 13, pl. 3A, figs. 1-3.- LOETTERLE, 1937, Nebraska Geol. Survey Bull. 12, p. 64, pl. 11, fig. 6.- van den BOLD, 1946, Contr. Study Ostracoda, p. 98, pl. 6, figs. 12a-c.

Cythereis _ponderosana_ ISRAELSKY, 1929, Arkansas Geol. Survey Bull. 2, p. 13, pl. 3A, figs. 5-8.

Cythere _ponderosana_ (Israelsky).- ALEXANDER, 1929, Texas Univ. Bull. 2907, pp. 83, 84, pl. VI, fig. 3.

Cythere _foersteriana_ Bosquet.- ALEXANDER, 1929, Texas Univ. Bull. 2907, p. 82, 83, pl. VI, figs. 1, 11.

Protocythere _paratriplicata_ SWAIN, 1952, U.S.G.S. Prof. Paper 234-B, Part 2, p. 85, pl. 9, figs. 18-21.- BROWN, 1958, North Carolina Dept. Conserv. & Dev., Div. Min. Res. Bull. 70, p. 16, pl. 3, figs. 16, 17.- BROWN, 1958, _ibid_. Bull. 72, p. 68, pl. 8, fig. 5.

Veenia _ozanana_ (Israelsky).- BUTLER and JONES, 1957, Louisiana Geol. Survey Bull. 32, p. 44, pl. 3, figs. 4a-3.- HOWE and LAURENCICH, 1958, Intro. to Study Cretaceous Ostracoda, p. 512, 513, 1 fig.- PAULSON, 1964, Jour. Pal., vol. 37, (in press)

Diagnosis.- Sexually dimorphous _Veenia_ with essentially smooth surface between ribs; large pit below anterior end of dorsal rib, smaller pit behind eye tubercle and anterior to downturned end of dorsal rib; other pits developed along ribs.

Dimensions.- Range of length in adults 0.55-0.91 mm., mean of females 0.60, mean of males 0.75; height 0.40-0.51, mean 0.45; width 0.29-0.40, mean 0.35.

Occurrence.- Veenia ozanana is rather common from the middle of the lower Austinian to the lower Navarroan. It is also widespread geographically, having been reported from the Atlantic Coast to the Great Plains.

Veenia bonhamensis PAULSON

Plate 1, figures 8, 9

Veenia bonhamensis PAULSON, 1964, Jour. Pal., vol. 37 (in press)

Diagnosis.- Small, sexually dimorphous Veenia with sharp ribs having pronounced pitting along inner sides.

Dimensions.- Length of illustrated specimens: male, 0.52 mm.; female, 0.45 mm.

Discussion.- Representatives of this species in the writer's collections from central and north-central Texas are slightly smaller than the forms Paulson (1964) illustrated from northeast Texas, but they are identical in all other respects.

Occurrence.- The species is rare in the lower Austinian in central and north-central Texas. Paulson (1964) reports it from the lower and upper Austinian in northeast Texas.

Veenia gapensis (ALEXANDER)

Plate 1, figures 12, 13

Cythere gapensis ALEXANDER, 1929, Univ. Texas Bull. 2907, p. 84, pl. 6, figs. 16, 17.- GANGER in Peterson et al., 1953, Utah Geol. Min. Survey Bull. 47, p. 11, figs. 9, 17, 18.- HOWE and LAURENCICH, 1958, Intro. to Study Cretaceous Ostracoda, p. 158, 2 figs.

Cythereis coalvillensis LANKFORD *in* Peterson *et al*., 1953, Utah Geol. Min. Survey Bull. 47, p. 97, pl. 16, fig. 1a-c.

Trachyleberis gapensis (Alexander).- BROWN, 1957, North Carolina Dept. Cons. and Devel. Bull. 70, p. 14, pl. 7, figs. 15-19.- BROWN, 1958, *ibid*. Bull. 72, p. 63, pl. 4, fig. 4.

Veenia gapensis (Alexander).- PAULSON, 1964, Jour. Pal., vol. 37 (in press).

Diagnosis.- Veenia with prominent crossribbing between longitudinal ribs; upturned posterior.

Dimensions.- Range of length 0.45-0.63 mm., mean of males 0.61, of females, 0.50; height 0.27-0.32, mean 0.29; width 0.27-0.30, mean 0.28.

Discussion.- This distinctively ornamented species has been reported from the Atlantic Coast (Brown, 1957, 1958) to the Utah and Wyoming area (Peterson *et al*. 1953). The form referred to the species by Ganger (*in* Peterson *et al*.) may belong to the species but it is difficult to tell from the illustration or description. On the other hand the form illustrated and described by Lankford in the same paper as *Cythereis coalvillensis* bears a strong resemblance to *Veenia gapensis* as far as can be judged from the illustration.

Occurrence.- The species ranges from the uppermost Austinian, Brownstown Marl of Arkansas, into the upper Tayloran. It is rather common in the Arkansas area in the lower Tayloran, but is known only from two samples from the "Lower Taylor" in central Texas.

GENUS *PHACORHABDOTUS* HOWE and LAURENCICH

Discussion.- Representatives of this genus first appear in North America in the upper Austinian in the form of *Phacorhabdotus simplex*. The genus ranges at least into the Paleocene as "*Brachycythere*" *formosa* Alexander. The origins of the genus may lie in such forms as "*Cythereis*" *semiplicata* (Reuss) of the Europian Turonian.

Phacorhabdotus simplex PAULSON

Plate 1, figures 7, 8

Phacorhabdotus simplex PAULSON, 1964, Jour. Pal., vol. 37 (in press)

Diagnosis.- Small *Phacorhabdotus* with weakly developed median rib; laterally compressed carapace; oblique anterodorsal outline in right valve because of strong overlap of left.

Dimensions.- Range of length 0.44-0.55 mm., mean 0.50; height 0.27-0.34, mean 0.31; width 0.19-0.21, mean 0.20.

Occurrence.- *P. simplex* ranges throughout the upper Austinian in central and north-central Texas and ranges into the lowermost Tayloran in the Dallas area. Paulson (1964) reports the species as ranging from the base of the Brownstown Marl to the top of the Gober Chalk in northeast Texas.

GENUS *HENRYHOWELLA* PURI

Discussion.- This genus has not been previously reported below the Eocene, but at least one species of the genus, *H. spoori* (Israelsky), occurs in the North American Upper Cretaceous.

Henryhowella spoori (ISRAELSKY)

Plate 1, figures 11, 18, 19

Cythereis spoori ISRAELSKY, 1929, Arkansas Geol. Survey Bull. 2, p. 487, pl. 4A, fig. 4,5.- PAULSON, 1964, Jour. Pal., vol. 37 (in press).

Cythereis? spoori Israelsky.-HOWE and LAURENCICH, 1958, Intro. Study Cretaceous Ostracoda, pp. 235, 236, 2 fig.

Veenia reticulata PAULSON, 1964, Jour. Pal., vol. 37 (in press)

Lectotype.- United States Nation Museum no. 80,254 A, right valve of a male, is hereby designated as the lectotype. This is cotype A of Israelsky (1929, pl. 4A, fig. 4).

Diagnosis.- Small, sexually dimorphous Henryhowella with prominent reticular surface; short spines at reticule junctions.

Dimensions.- Range of length 0.46-0.62 mm., mean males 0.59, females 0.50; height 0.27-0.34, mean 0.30.

Discussion.- This species resembles the type species of the genus, Henryhowella evax, differing from it principally in size. The form described as Veenia reticulata by Paulson (1964) from the Bonham Clay is identical to inferred females of H. spoori in the writer's collections.

Occurrence.- H. spoori is rare in central Texas having been found in only one sample from the "Lower Taylor" and one from the Austin. It was reported by Paulson (1964), as Veenia reticulata, from the Bonham Clay in northeast Texas. H. spoori occurs abundantly in the Brownstown Marl and rarely in the lowermost part of the Ozan Formation in south-western Arkansas.

GENUS COSTA NEVIANI 1928

Discussion.- Prior to this paper, the oldest species from North America that had been referred to this genus was one from the Claibornian Eocene by Howe (1963). The species herein described as a Costa possesses the essential characters of the genus and is a Costa of the C. batei (Brady) type.

Costa redunca HAZEL, n. name

Plate 1, figures 1, 2

Cythereis pidgeoni (Berry).- PAULSON, 1964, Jour. Pal., vol. 37 (in press).

not Cytheridea pidgeoni BERRY, 1925, Am. Jour. Sci., 5th ser., vol. 9, p. 485, figs. 7, 8.

Etymology.- Reduncus (Latin), bent backward, in reference to the looped ventral ri .

Holotype.- H. V. Howe collection, Louisiana State University, no. 7560, right valve of a male.

Paratypes.- H. V. Howe collection, no. 7561; United States National Museum no. 132342.

Type locality.- 2B-1

Diagnosis.- Small, sexually dimorphous Costa with cross ribbing between longitudinal ribs; recurved ventral rib.

Dimensions.- Rnage of length 0.46-0.57 mm., mean males 0.56, females 0.49; height 0.46-0.51, mean 0.49; width (one female carapace) 0.22.

Description.- Carapace saggitate in dorsal view, widest behind the middle; posterior compressed; left valve larger, overlapping at cardinal angles; there is a row of pits between anterior rim and denticulate margin and between dorsal rib and contact margin; high median rib prominent. In ventral view ventral ribs recurve around large depressed area on ventrolateral surface of each valve.

Laterally subrectangular (inferred males) to subrhomboidal (inferred females); anterior broadly rounded, denticulate with high rim angled towards margin; posterior angulate above the middle, downturned, denticulate with low rim.

Valves ornamented with small eye tubercle at anterodorsal end of rim; dorsal rib starting at eye tubercle running towards posterior, forming dorsal outline, angulate posterodorsally, faintly traceable around posterior as low rim; high, narrow median rib angled downward at posterior end; ventral rib begins in anteroventral area runs towards posterior, turns sharply downward in posteroventral area, curves under and continues towards anterior, ending just posterior and below where it began--two to four pits usually present on ventral rib at the downward curvature; series of evenly spaced, low cross-ribs connecting the longitudinal ribs.

Ocular sinus prominent; marginal areas of moderate width, line of concresence coinciding with inner margin or deviating slightly; approximately 20 straight radial canals around anterior and 12 around posterior. Hinge amphidont, anterior tooth of right stepped, peglike followed by shallow postjacent socket connected to an elliptical, essentially smooth posterior tooth set at an upward angle, by a crenulate furrow. Adductor muscle scars a vertical row of four closely spaced scars (third scar from bottom more elongate); large "C" -shaped scar in front of adductors usually obscured by surface ornamentation.

Discussion.- This species closely resembles _Costa batei_ (Brady), but differs from it in being smaller and more strongly dimorphous and in having well-developed cross ribs and a recurved ventral rib. It is distinguished from "_Cythereis_" _pidgeoni_ (Berry), in addition to internal differences, by having the recurved ventral rib and in not possessing the bifid median rib of that species.

GENUS _DIVERSIPELLIS_ HAZEL, N. Gen.

Type species.- _Cythereis bicornis_ Israelsky, 1929.

Etymology.- _Diversus_ (Latin), diverse or different; _pellis_ (Latin), skin; in reference to the variable surface ornamentation.

Diagnosis.- Trachyleberididae with laterally subrectangular to subtriangular carapaces; sagittate outline in dorsal view; anterior and posterior compressed, rimmed, usually denticulate.

Valves ornamented with short dorsal rib; curved, sometimes weakly developed middle rib, separate from muscle node; ventral rib on which a depression may be developed just anterior to posteroventral spine; small curved ridge present running from glassy eye tubercle toward muscle node; smooth, pitted or reticulate surface.

Marginal areas narrow, traversed by few straight radial canals; line of concrescence coincides or deviates slightly from inner margin; normal canals small, scattered; ocular sinus prominent; hinge amphidont with conoid anterior tooth and tear-shaped posterior tooth in right valve.

Dimorphism not readily apparent, inferred males somewhat longer than females.

Discussion.- The species of this genus form a distinct group in the Upper Cretaceous of the Coastal Plain. The oldest known species, and probable progenitor of the others, is Diversipellis bicornis (Israelsky) which has been reported from the Eaglefordian of North Carolina (Swain, 1952). However, it is not known to occur in the Eaglefordian of Texas, though it does appear in the earliest Austinian. The youngest known species is D. taylorensis (Paulson) which ranges into the lower Tayloran of central and northeast Texas. The genus is distinguished from Cythereis by its distinctive outline in dorsal view and the narrow dorsum and venter. The presence of a muscle node and absence of distinct alae as well as a generally more complex ornamentation serve to separate it from Pterygocythereis and possibly was derived from such species as Pterygocythereis? sp. (Pl. 2, fig. 21) from the Eaglefordian.

Diversipellis bicornis (ISRAELSKY)

Plate 2, figures 8-12

Cythereis bicornis ISRAELSKY, 1929, Arkansas Geol. Survey Bull. 2, p. 19, pl. 4A, fig. 10a-c.- ALEXANDER, 1929, Texas Univ. Bull. 2907, p. 100, pl. 8, figs. 4,5.- SWAIN, 1952, U. S. G. S. Prof. Paper 234B, Part 2, p. 83, pl. 9, fig. 31.- HOWE and LAURENCICH, 1958, Intro. to Study Cretaceous Ostracoda, pp. 183,184, 1 fig.- PAULSON, 1964, Jour. Pal., vol. 37 (in press)

Cythereis cf. C. bicornis (Israelsky).- SWAIN, 1948, Maryland Dept. Geol., Mines, and Water Res. Bull. 2, p. 200, pl. 14, figs. 15, 16.

Diagnosis.- Diversipellis with somewhat acuminate posterior; surface ornamented with ribs and riblets.

Dimensions.- Range of length 0.55-0.70 mm., height 0.30-0.34, width 0.30-0.36.

Discussion.- This species is divisible into two forms which succeed one another through time and are herein proposed as successional subspecies. A second species, D. taylorensis (Paulson) is apparently derived directly from the younger of the subspecies. The evolutionary tendencies within this lineage are to become more acuminate posteriorly and more tumid centrally; to develop a smoother surface, but thicker ribs; and to develop a sulcus in the ventral rib anterior to the posterodorsal spine. The spine itself tends to become sharper and more elongate normal to the carapace length.

Different stages in the evolution of these chronoclinal characters can be used to separate taxa, particularly where the development of one character parallels another. The point of separation is necessarily arbitrary, since no convenient, temporally important hiatuses occur in the section. However, as McAlester (1962, p. 1380) points out, the arbitrary selection of a starting point does not make the genetic interval between boundaries any less real. It is believed that the average form of each of the subspecific taxa delineated herein is separated from its vertically contiguous kin by a degree of morphologic distinctiveness consistent with the separation of geographic subspecies in paleontology or neontology.

Occurrence.- This species is one of the more common and widespread taxa in the Gulf Cretaceous. It has been reported from the Atlantic Coast, from Maryland and North Carolina, is known to occur in the Mooreville Chalk in Alabama, is abundant in the Austinian of the Western Gulf and ranges into the lowermost Tayloran.

<u>Diversipellis bicornis bicornis</u> (ISRAELSKY)

Plate 2, figures 8, 9

Diagnosis.- <u>Diversipellis bicornis</u> with several cross riblets between longitudinal ribs forming an irregular, large reticular pattern (sometimes with accessory pitting); bifurcation in ventral rib anterior to posteroventral spine, one branch going to spine, the other below it.

Dimensions.- Range of length 0.55-0.70 mm., mean 0.60; height 0.30-0.34, mean 0.30; width 0.34-0.38, mean 0.36.

Discussion.- This subspecies is distinguished from <u>D</u>. <u>bicornis rectangula</u>, n. subsp., by its more pointed posterior and by the bifurcation in the ventral rib. It can be separated from <u>D</u>. <u>taylorensis</u> by its more ornate surface and in not possessing the very acuminate posterior of the latter. There is some geographical variation within the subspecies with forms from some areas, particularly the Waco and Dallas areas, tending to have accessory pitting over the surface.

When Israelsky (1929) described <u>D</u>. <u>bicornis</u> he stated that the holotype came from the Tokio Sand. However, Thorsen (1959 ms) did not report the subspecies from the Tokio and the writer has not found it in the lower Austinian elsewhere. It is probable that Israelsky's specimens came from the overlying Brownstown Marl rather than the Tokio.

<u>Diversipellis bicornis rectangula</u> HAZEL, n. subsp.

Plate 2, figures 10-12

Etymology.- <u>Rectus</u> (Latin), right; <u>angulus</u> (Latin), angle; in reference to the lateral outline.

Holotype.- H. V. Howe Collection, Louisiana State University, no. 7562, a left valve.

Paratypes.- H. V. Howe Collection, no. 7563; United States National Museum no. 132343.

Type locality.- Locality M-1

Diagnosis.- Diversipellis bicornis with subrectangular lateral outline, the posterior tending to be rounded, particularly in the left valve; finely reticulate surface; weakly developed middle rib;, no prominent depression in ventral rib anterior to weakly developed posteroventral spine.

Dimensions.- Range of length 0.57-0.65 mm., mean 0.61; height 0.30-0.34, mean 0.31; width 0.30-0.36, mean 0.34.

Discussion.- This subspecies is ancestral to D. b. bicornis and possibly, thereby, the other Diversipellis described herein. It is distinguished from D. b. bicornis by its more rounded posterior and absence of the depression and bifurcation in the ventral rib.

Diversipellis taylorensis (PAULSON)

Plate 2, figures 1, 2

Cythereis taylorensis PAULSON, 1964, Jour. Pal., vol. 37 (in press)

Diagnosis.- Diversipellis with very acuminate posterior; nearly smooth surface between large, rounded ribs.

Dimensions.- Range of length 0.53-0.63 mm., mean 0.58; height 0.25-0.32, mean 0.28; width 0.34-0.36, mean 0.35.

Discussion.- The species appears to be directly derived from D. bicornis bicornis. However, the overlap between D. taylorensis and D. b. bicornis is not great in most areas, in contrast to the overlap of the latter taxon with its progenitor. This seems to be because of an accelerated rate of evolution with a change in environment -- a release in selection pressure. Thus taylorensis first appeared in northeast Texas where argillaceous sediments were time equivalents of calcareous deposits to the southwest.

Occurrence.- In central Texas the species occurs primarily in lower Tayloran rocks, but ranges into the uppermost Austinian. In northeast Texas it is found in the upper Austinian and lower Tayloran (Paulson, 1960 ms; 1964).

Diversipellis niobrarensis (MORROW)

Plate 2, figures 6, 7

Cythereis niobrarensis MORROW, 1934, Jour. Pal. vol. 8, p. 203, pl. 31, figs. 6, 10a-c.- ?LOETTERLE, 1937, Nebraska Geol. Survey Bull. 12, pl. 54, pl. 9, fig. 2a,b.- PAULSON, 1964, Jour. Pal., 1964, Jour. Pal., vol. 37 (in press)

?Cythereis coryelli LOETTERLE, 1937, Nebraska Geol. Survey Bull. 12, p. 55, pl. 9, fig. 3a,b.

Diagnosis.- Diversipellis with reticulate surface; reduced middle rib; ventral rib segregated into a row of short spines.

Dimensions.- Range of length 0.57-0.68 mm., mean 0.62; height 0.29-0.36, mean 0.33.

Discussion.- This species seems to be an early derivitive from D. bicornis rectangula. It is more reticulate than that species, however, and also differs in having a row of short spines or nodes in place of a ventral rib.

Occurrence.- Diversipellis niobrarensis was found in the lower Austin in central Texas and the upper Austinian of northeast and north-central Texas. Morrow (1934) and Loetterle (1937) report the species from the Fort Hays Limestone of the Great Plains region. However, Loetterle's illustrations and descriptions are reminiscent of D. bicornis bicornis, particularly those more pitted varieties found in the Dallas area. Cythereis coryelli was described a "thin and fragile" and coextensive with niobrarensis of Loetterle and the writer suspects that it may be a molt of the latter.

Diversipellis alexanderi (MORROW)

Plate 2, figures 4, 5

Cythereis alexanderi MORROW, 1934, Jour. Pal., vol. 8, p. 203, pl. 31, figs. 14a-c.- HOWE and LAURENCICH, 1958, Intro. Study Cretaceous Ostracoda, pp. 179,180, 2 figs.

Diagnosis.- Diversipellis with pitted surface, very denticulate extremities, slightly alate ventral rib.

Dimensions.- Range of length in adults 0.59-0.70 mm., mean 0.64; height 0.32-0.40, mean 0.35.

Discussion.- This species is somewhat alate in contrast to the other species of this genus listed herein. There is a tendency to develop a blade spine on the posterior margins of the alae and this may be more evidence for a genetic relationship between Diversipellis and Pterygocythereis. However, this type of structure is present in other unrelated alate genera.

Occurrence.- This species was found only in the Big House Chalk in Travis and Bell Counties. Morrow (1934) reported it from the lower part of the Niobrara Chalk, the Fort Hays Limestone. It appears that it developed to the north and migrated into the Texas area as no clearcut relationship to any of the Diversipellis in this area could be established.

GENUS *ISOCYTHEREIS* TRIEBEL

Discussion.- While working on three closely related species which were enigmatic as to generic position--particularly in the light of conclusions drawn about the genus *Trachyleberidea* (see p.16)--it was suggested to the writer by W. A. van den Bold that the species bore at least a superficial resemblance to the type species of *Isocythereis*, *I. fissicostis* Triebel. Following this lead the species, as well as some possible Tertiary representatives, were compared to species of *Isocythereis* illustrated and described by Triebel (1940).

Externally the Lower and Upper Cretaceous and Tertiary species compare quite favorably. There are, however, some internal differences. The Lower Cretaceous species have a stepped anterior tooth, whereas the Upper Cretaceous and Tertiary species have a more peg-like or conoid tooth. The Lower Cretaceous species have an elongated, right triangular, multilobate posterior tooth. The Upper Cretaceous and Tertiary species have a lobate, bulbous posterior tooth. As demonstrated by Pokorny (1955), the stepped anterior tooth is a primitive feature and the conoid or peg-like tooth has probably developed from it. Likewise the right triangular type of posterior tooth is a primitive feature. The Upper Cretaceous species seem to be intermediate, as should be expected, in development between those of the Lower Cretaceous, represented by the type species, and those of the Tertiary, represented by such species as "*Cythereis*" *aranea* Jones and Sherborn.

The oldest known of the Gulf Upper Cretaceous species seems to be *Isocythereis austinensis* which apparently gives rise to *I. hadraina* early in the Austinian. Isocythereis hadraina can be divided into two successional subspecies on the basis of progressional changes in surface morphology. The hadraina lineage is a branching which seems to trend away the main genetic strain of the genus; Cythereis? bonnemai Triebel may have somewhat the same relationship to Isocythereis fissicostis.

The Upper Cretaceous and Tertiary species of the genus examined by the writer posses a muscle scar pattern which consists of a vertical row of adductor scars with a J- or U- shaped scar in front. In contrast, Triebel (1940) described a peculiar pattern of many scars for the species Isocythereis fortinodis. The writer suggests that either this is an anomalous pattern or thatthe true pattern was obscured by the reticular surface ornamentation.

Isocythereis austinensis (ALEXANDER)

Plate 2, figures 14-16

Cythereis austinensis ALEXANDER, 1929, Univ. Texas Bull. 2907, p. 99, pl. 7, fig. 11.- HOWE and LAURENCICH, 1958, Intro. to Study Cretaceous Ostracoda, p. 182, 1 fig.- PAULSON, 1964, Jour. Pal., vol. 37 (in press)

Diagnosis.- Sexually dimorphous Isocythereis with pitted surface; long ventral rib that turns upward anterior to muscle node, doubly rimmed anterior.

Dimensions.- Range of length 0.44-0.59 mm., mean of males 0.58, mean of females 0.47; height 0.27-0.29, mean 0.28; width 0.21-0.24, mean 0.22.

Occurrence.- The species occurs in the lower Austinian from central to northeast Texas and ranges into the lower part of the upper Austinian in these areas. It is most common in the "Middle Marl" and lowermost "Upper Chalk" in the Dallas area.

Isocythereis hadraina (PAULSON)

Plate 2, figures 17, 18, 25, 26

Cythere semiplicata (Reuss).- ALEXANDER, 1929, Texas Univ. Bull. 2907, p. 80, pl. 6, figs. 9, 15.

not Cytherina semplicata REUSS, 1846, Versteinerungen der böhmischen Kreide Formation, Abt. II, p. 104, pl. 24, fig. 16a,b.

Cythereis semiplicata (Reuss).- LOETTERLE, 1937, Nebraska Geol. Survey Bull. 12, p. 62, pl. 11, fig. 7.

Cythereis hadraina PAULSON, 1964, Jour. Pal., vol. 37 (in press)

Diagnosis.- Sexually dimorphous Isocythereis with normal pore pustules scattered over an otherwise smooth surface and along ribs.

Dimensions.- Range of length 0.53-0.76 mm.; height 0.32-0.38; width 0.25-0.31.

Discussion.- In the lowermost Austinian specimens of this species have the median rib connected to the muscle node and have posterior cross ribs running down from the dorsal rib and up from the ventral rib towards, and sometimes connected to, the middle rib. Also in this part of the section specimens usually possess a short, thick rib running towards the anteroventral area from the muscle node.

Traced upwards through the Austinian, the cross ribs undergo a reduction in size and retreat towards the dorsum and venter. The anteroventral rib also tends to undergo a reduction in size. A sulcus begins to develop in the middle rib eventually separating the rib from the muscle node. The species can be divided into two successional subspecies on the basis of these morphologic changes.

Occurrence.- The species is rather common in the lower Austinian and very abundant in the upper Austinian in central, north-central and northeast Texas. It ranges into the lowermost Tayloran in central and northcentral Texas and in Arkansas.

Isocythereis hadraina orchama HAZEL, n. subsp.

Plate 2, figures 17, 18

Etymology.- Orchamos (Greek), first or initial; in reference to it being the older subspecies.

Holotype.- H. V. Howe Collection, Louisiana State University, no. 7564, left valve of a male.

Paratypes.- H. V. Howe Collection no. 7565; United States National Museum no. 132344.

Type locality.- T-3

Diagnosis.- Isocythereis hadraina with median rib connected to muscle node and prominent posterior cross ribs.

Dimensions.- Range of length 0.53-0.67 mm., mean of females 0.55, mean of males 0.64; height 0.32-0.38, mean 0.34.

Discussion.- This subspecies differs from its descendant, I. hadraina hadraina, in possessing the cross ribs and middle rib connected to the muscle node. It differs from I. austinensis, from which it is probably derived, in being slightly larger, less compressed and in not being strongly pitted.

Occurrence.- The subspecies is rather common in the lower Austinian from central to northeast Texas and ranges into the lower part of the upper Austinian.

Isocythereis hadraina hadraina (PAULSON)

Plate 2, figures 25,26

Diagnosis.- Isocythereis hadraina with middle rib separated from muscle node; poterior crossribs reduced or absent.

Dimensions.- Range of length 0.53-0.65 mm., mean of females 0.55, mean of males 0.63; height 0.34-0.38, mean 0.36.

Discussion.- This subspecies differs from its progenitor, I. h. orchama, in not possessing the well-developed posterior cross ribs and in having the muscle node separate from the middle rib.

Occurrence.- The subspecies is very abundant in the upper Austinian, particularly in central and north-central Texas. It ranges into the lowermost Tayloran in these areas and also occurs in the lower Tayloran of Arkansas.

Isocythereis aff. I. austinensis (ALEXANDER)

Plate 2, figure 13

Diagnosis.- Isocythereis with coarsely pitted surface; median rib weakly connected to muscle node; short ventral rib; very denticulate extremities; peglike anterior tooth in hinge of right valve and bulbous, slightly lobate posterior tooth.

Dimensions.- Average length of three adult specimens 0.60 mm; height 0.36; width of one specimen 0.27.

Discussion.- This species is closely related to I. austinensis, but can be distinguished from it by the shorter ventral rib, more irregularly pitted surface and weaker connection between the median rib and muscle node. Also the hinge elements are more robust.

Occurrence.- The species was found in the "Lower Taylor" in Dallas and Delta Counties and the Pecan Gap Chalk in Williamson County.

GENUS PTERYGOCYTHEREIS BLAKE, 1933

Discussion.- Howe (1961), p. Q260) stated that Alatacythere Murray and Hussey is identical in all essential features except hinge to Pterygocythereis, the hinge of Alatacythere being hemiamphidont and that of Pterygocythereis holamphidont.

Viewed in proper perspective the hinge is a valuable taxonomic character and its use and phylogenesis have been pointed out by Pokorný (1955, 1957), Sylvester-Bradley (1956) and Hanai (1961), but when used as the ultimate basis of separation the character is made taxobasic (from taxobases, a term used by Cox in 1960 for characters which are used to group organisms together without regard to evolution) and leads to spurious groupings (i.e. Beroušek, 1952, and Schweyer, 1949). Pokorný (1957) and Hanai (1961) show that the value of the hinge need not be great and that its structures are homologous with those of the free margin. The free margin structures being more stable, but less conspicuous, than the hinge.

Pterygocythereis, as considered here, first becomes typically developed in the North American Cretaceous in the lower Austinian. Pterygocythereis? sp., illustrated on Plate 2, figure 21, occurs in the Eaglefordian and may possibly be the ancestor, or at least related to the ancestral group, of the more typical Pterygocythereis.

As pointed out by Hill (1954, p. 808) the genus may have a smooth or crenulate posterior tooth. Which type of a tooth, or teeth, is developed in a particular species can be correlated with other aspects of the carapace morphology (see Pokorný, 1957). Although there is a general evolutionary tendency to develop a smooth posterior tooth in the right valve, the crenulate, thin, right triangle-shaped teeth are found primarily in species which are very thin shelled. The larger, ovate, rounded posterior teeth are found in the thicker, shelled species.

Thus many of the older species, including what may be the progenitor, have amphidont hinges in which the posterior tooth is smooth while later and coeval species have crenulate as well as smooth teeth. This does not follow a rigid hemiamphidont to holampnidont evolutionary pattern as some have thought, so in order to establish a more phylogenetic grouping the genus Alatacythere is considered to be a junior synonym of Pterygocythereis. Hill (1954) also reached this conclusion, but for somewhat different reasons.

Pterygocythereis is often carried in the family Brachycytheridac; however, as Hill (1954) pointed out, Pterygocythereis is a winged Cythereis s.l., while Pterygocythere, which is homeomorphic with Pterygocythereis, is a winged Brachycythere. Pterygocythereis was placed in the Trachyleberididae on the basis of soft parts by Neale (1959).

Pterygocythereis ponderosana (ISRAELSKY)

Plate 2, figure 28

Cytheropteron ponderosana ISRAELSKY, 1929, Arkansas Geol. Survey Bull. 2, p. 9, pl. 2A, fig. 1a-c.

Cythereis thomasi ISRAELSKY, nom. nov., in Alexander, 1933, Jour. Pal., vol. 7, p. 211, pl. 25, figs. 16a,b.- ?PETERSON, 1953, Utah Geol. Min. Survey Bull. 47, p. 49, pl. 3, figs. 5-9.

?<u>Pterygocythereis</u> <u>thomasi</u> (Israelsky).- HILL, 1954, Jour. Pal., vol. 28, p. 816, pl. 98, figs. 5a-c; pl. 99, figs. 2a-c.

<u>Pterygocythereis</u> <u>nadeauae</u> HILL, 1954, <u>ibid</u>., p. 818, pl. 98, figs. 6a-3 (part); pl. 100, figs. 1a-h (part).

<u>Alatacythere</u> cf. <u>A</u>. <u>nadeauae</u> (Hill).- BUTLER and JONES, 1957, Louisiana Geol. Survey Bull. 32, p. 30, pl. 2, figs. 1a-c.

<u>not</u> <u>Alatacythere</u> <u>ponderosana</u> (Israelsky).- BUTLER and JONES, <u>ibid</u>., p. 29, pl. 2, figs. 4a-c.

<u>Alatacythere</u> <u>ponderosana</u> (Israelsky).- HOWE and LAURENCICH, 1958, Intro. to Study Cretaceous Ostracoda, p. 42, 2 figs.-?PAULSON, 1964, Jour. Pal., vol. 37 (in press).

Diagnosis.- Quadrate, thin shelled <u>Pterygocythereis</u> with prominent alae.

Dimensions.- Observed range of length in five specimens 0.86-1.00 mm.

Discussion.- It seems somewhat incongruous that such a relatively unimportant species should have so complex a nomenclatural history. It does serve to point out that the more typical representatives of this genus are most difficult to work with and identification without comparison to type material is risky.

The holotypes of <u>Cytheropteron</u> <u>ponderosana</u> Israelsky and <u>Pterygocythereis</u> <u>nadeauae</u> Hill are both in the United States National Museum; they were compared and found to be conspecific; however, the broken paratype illustrated by Hill is probably another species. The specimens illustrated by Butler and Jones as <u>ponderosana</u> are too quadrate and too small. Paulson's species is also rather small and more angulate at the posterior.

Occurrence.- The species was found to be rare in the Austinian and apparently ranges at least into the lower part of the upper Tayloran.

Pterygocythereis tokiana (ISRAELSKY)

Plate 2, fig. 27

Cytheropteron tokiana ISRAELSKY, 1929, Arkansas Geol. Survey Bull. 2, pl. 1A, figs. 8, 9a,b.

Cythereis tokiana (Israelsky).- LOETTERLE, 1937, Nebraska Geol. Survey Bull. 12, p. 55, pl. 9, figs. 4a,b.

not Cythereis (Pterigocythereis) tokiana (Israelsky).- van den BOLD, 1946, Contr. to Study Ostracoda, p. 100, pl. 6, fig. 9.

Pterygocythereis cf. P. tokiana (Israelsky).- SWAIN, 1952, U.S.G.S. Prof. Paper 234-B, Part 2, pp. 85-86, figs. 1-3.

Pterygocythereis tokiana (Israelsky).- HILL, 1954, Jour. Pal., vol. 28, p. 817.

Alatacythere tokiana (Israelsky).- HOWE and LAURENCICH, 1958, Intro. to Study Cretaceous Ostracoda, p. 45, 2 figs.- PAULSON, 1964, Jour. Pal., vol. 37 (in press)

Diagnosis.- Subrectangular Pterygocythereis with frilled dorsal rib extending vertically; an anterodorsal frill; on well preserved specimens, denticulate posterior.

Dimensions.- Range of length in adults 0.72-0.99 mm., height 0.36-0.52.

Discussion.- In many samples from Austinian and lower Tayloran, a form occurs, never in abundance, which is nearly indentical to Pterygocythereis tokiana (Israelsky) except it is smaller. The dimensions given by Israelsky (1929), Alexander (1933), and Howe and Laurencich (1958) for the species all approach one millimeter -- the species described by Howe and Laurencich (1958, p. 41, 42) as Alatacythere nadeauae is probably also tokiana -- but only a few specimens found by the writer approach these dimensions, most being about 0.78 mm. It is probable that two species or more are represented in this grouping.

Pterygocythereis burdittensis (PAULSON)

Plate 2, figs. 22, 23

Alatacythere burdittensis PAULSON, 1964, Jour. Pal., vol. 37 (in press).

Diagnosis.- Subquadrate, tumid Pterygocythereis with weakly developed ventral alae, on posterior border of which is a blade spine, above this a small tubercle; short centrodorsal rib terminating in a spine.

Dimensions.- Range of length in adults 0.70-0.78 mm., mean 0.73; height 0.38-0.46, mean 0.41; width 0.34-0.42, mean 0.38.

Discussion.- This distinctive species must have been an immigrant into central and northeast Texas, as it does not seem likely that any species with a prior history in the area could have been ancestral to it. It is somewhat divergent from the norm of Pterygocythereis with its reduced ventral alae, which appear less developed than they really are because of the tumidity of the carapace.

Occurrence.- The species is common and abundant in the Upper Austinian in central Texas, less so in northeast Texas and does not occur in Arkansas.

Pterygocythereis ingens HAZEL, n. sp.

Plate 2, figures 29, 30

Etymology.- Ingens (Latin), vast or huge, in reference to the large size.

Holotype.- H. V. Howe Collection, Louisiana State University, no. 7566, a right valve.

Paratype.- United States National Museum no. 132345.

Type locality.- H-1

Diagnosis.- Large, rectangular Pterygocythereis with very large alae; frill-like dorsal rib with hooked spine at posterior end.

Dimensions.- Range of length 1.02-1.20 mm., mean 1.10; height 0.55-0.61, mean 0.58; width 0.93-0.95, mean 0.94.

Description.- Viewed dorsally; broadly sagittate, dorsal surface narrow, ridged; left valve larger overlapping right at cardinal angles; eye tubercles prominent.

Viewed laterally; quadrate, anterior and posterior broadly rounded, rimmed, denticulate; highest at anterior cardinal angle. Surface ornamented with frilled dorsal rib with hooked spine at posterior; extremely alate ventral rib directed posteriorly with blade spine located on posterior border, dorsal margin of alae with rectangular pits which extend partially around anterior.

Marginal areas narrow with few straight radial canals, grouped or solitary; ocular sinus prominent; hinge amphidont, anterior tooth of right peglike followed by small oval socket which opens dorsally into narrow groove extending anterior of anterior tooth and posterior connecting to elliptic, multilobate posterior tooth.

Discussion.- This species, though not common, is very distinctive and easily recognized by its large size.

Occurrence.- This species was found in the Burditt Chalk Marl and Big House chalk in central Texas.

Pterygocythereis compressa (PAULSON)

Plate 2, figures 19, 20

Alatacythere compressa PAULSON, 1964, Jour. Pal., vol. 37 (in press).

Diagnosis.- Pterygocythereis with elongate subrectangular carapace; ventral row of projecting spines instead of ala.

Dimensions.- Range of length 0.57-0.61 mm., mean 0.60; height 0.29-0.32, mean 0.31.

Discussion.- This species differs from other Cretaceous members of the genus in not having alae, but a row of hollow spines instead. The type species of the genus also has a row of spines.

Occurrence.- The species is absent in the Austinian of central Texas, but occurs rather abundantly in the Brownstown Marl of Arkansas. It is also found in the Austinian formations of northeast Texas and ranges into the Tayloran of central Texas and Arkansas.

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PLATE I

All figures approximately X 50

1-2 <u>Costa</u> <u>redunca</u> Hazel, n. name

1, exterior of right valve of a male (holotype); 2, exterior of left valve of female. Specimens from the Buckrange Sand Member of the Ozan Formation, southwestern Arkansas (sample 2B-1).

3-5 <u>Trachyleberidea</u> <u>anocula</u> (Paulson)

3, exterior of left valve; 4, exterior of right valve with small foraminifers adhering to valve; 5, dorsal view of carapace. Specimens from the "Upper Chalk" in Dallas County, Texas (valves from sample W-1, carapace from O-1).

6-7, 15 <u>Phacorhabdotus</u> <u>simplex</u> Paulson

6, exterior of left valve; 7, exterior of right valve; 15, dorsal view of carapace. Left valve from the "Middle Marl" in Dallas County (sample T-1), right valve from the "Upper Chalk" in Dallas County (sample P-1), carapace from the Big House Chalk in Travis County, Texas (sample E-3).

8-9 <u>Veenia</u> <u>bonhamensis</u> Paulson

8, left valve of a female; 9, right valve of a male. Specimens from the lower Austin in Travis County, Texas (sample M-2).

10 "<u>Cythereis</u>" <u>caudata</u> Butler and Jones

10, exterior of left valve. Specimen from the "Upper Chalk" in Dallas County, Texas (sample P-1).

11, 18, 19 <u>Henryhowella</u> <u>spoori</u> (Israelsky)

11, dorsal view of a female carapace; 18, exterior of right valve of a female; 19, exterior of left valve of a male. Carapace and left valve from the Buckrange Sand Member of the

Ozan Formation, southwestern Arkansas (sample 2B-1); right valve from the Durango Sand in Falls County, Texas (sample G-8).

12-13 Veenia gapensis (Alexander)

12, exterior of left valve; 13, exterior of right valve. Left valve from the Brownstown Marl, southwestern Arkansas (sample 2C-1); right valve from the "Lower Taylor" Marl in Falls County, Texas (sample G-10).

14 Veenia ozanana (Israelsky)

14, exterior of left valve of a male. Specimen from the "Upper Chalk" in Dallas County, Texas (sample R-1).

16-17, 23 Cythereis dallasensis Alexander

16, exterior of an abraded right valve showing the reticular surface ornamentation; 17, exterior of left valve; exterior of a slightly abraded left valve showing both reticular and hispid ornamentation; 23, exterior of a well preserved left valve with the hispid ornamentation largely masking the reticular pattern. Right valve from the Big House Chalk in Travis County, Texas (sample E-3); 17 from the Dessau Chalk in Bell County Texas (sample 2H-1); 23 from the "Lower Taylor" Marl in Travis County, Texas (sample D-3).

20 Trachyleberid species, genus uncertain

20, exterior of left valve. Specimen from the Big House Chalk in Travis County, Texas (sample B-10). This species is very rare and its taxonomic position is uncertain. It appears to be related to species of the "Cythereis" hannai type and possibly to species of the "Cythereis" cancellosa Alexander type.

21, 26 "Cythereis" hannai Israelsky

21, exterior of right valve of a male; 26, exterior of a right valve of a female. Male from the Buckrange Sand Member of the Ozan Formation, southwestern Arkansas (sample 2B-1); female from the Brownstown Marl of southwestern Arkansas (sample 2D-1).

22, 25, 31 Bradleya crassicarinata (Paulson)

22, exterior of right valve of a male; 25, exterior of left valve of a male; 31, dorsal view of a male carapace. Specimens from the "Lower Taylor" Marl in Travis County, Texas (sample D-1).

24, 30 Bradleya rugosissima (Alexander)

24, exterior of right valve; 30, exterior of left valve. Specimens from the "Lower Taylor" Marl in Travis County, Texas (right valve from sample D-2, left valve from C-7).

27-29 Bradleya plummeri (Israelsky)

27, exterior of abraded left valve showing reticular surface ornamentation; 28, exterior of a well preserved right valve with hispid surface; 29, dorsal view of carapace. Left valve from the Wolfe City Sand in Falls County (sample G-9); right valve and carapace from the "Lower Taylor" Marl in Travis County, Texas (sample C-9).

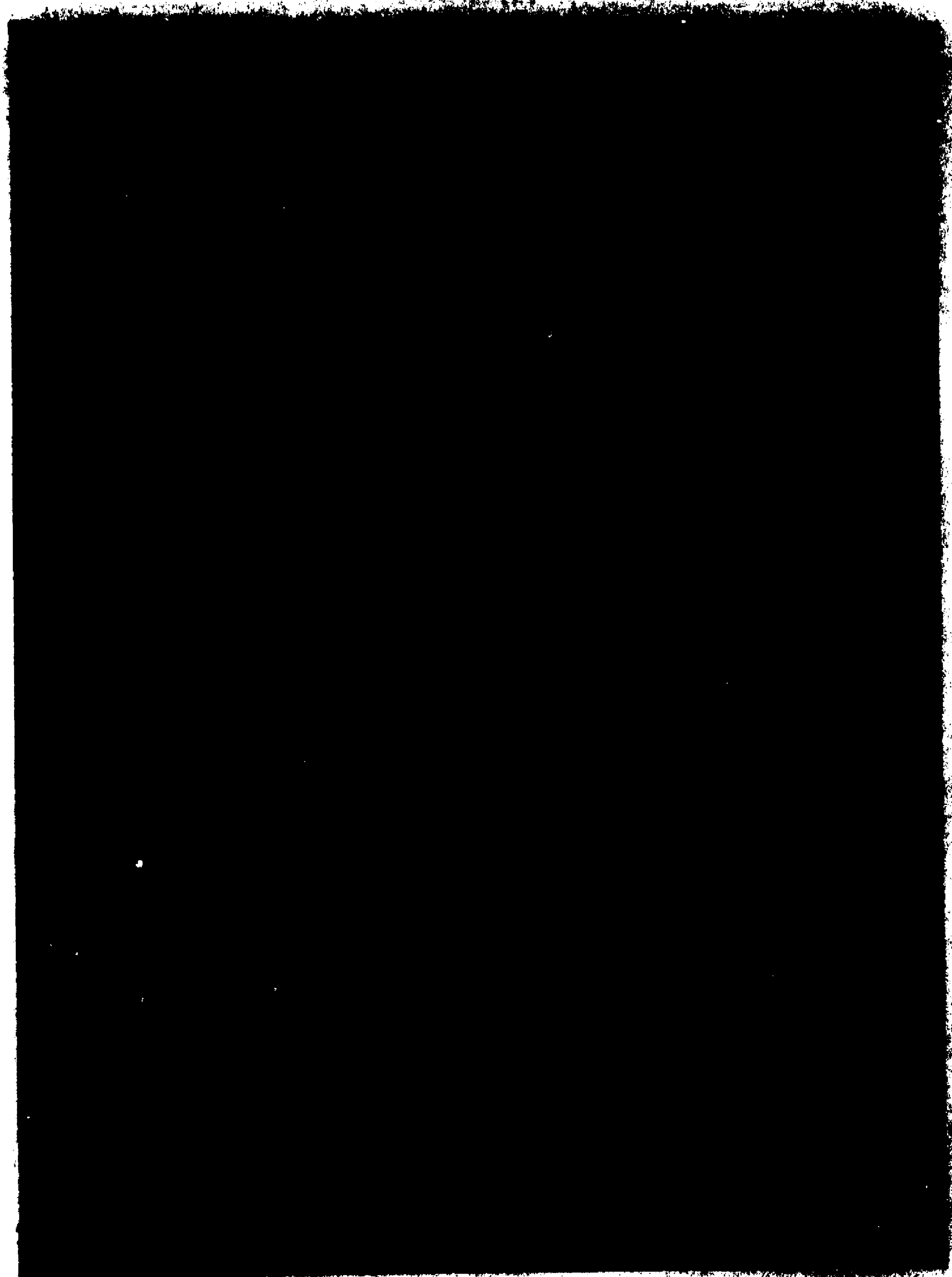

Plate I

PLATE II

All figures approximately X 50

1-3 *Diversipellis taylorensis* (Paulson)

1, exterior of left valve; 2, exterior of right valve; 3, dorsal view of carapace. Specimens from the "Lower Taylor" Marl in Travis County, Texas (sample D-2).

4-5 *Diversipellis alexanderi* (Morrow)

4, exterior of left valve; 5, exterior of right valve. Specimens from the Big House Chalk in Travis County, Texas (sample C-2).

6-7 Diversipellis niobrarensis (Morrow)

6, exterior of right valve; 7, exterior of left valve. Right valve from the lower Austin in McLennan County, Texas (sample 2I-1); left valve from the "Upper Chalk" in Dallas County, Texas (sample O-1).

8-9 *Diversipellis bicornis bicornis* (Israelsky)

8, exterior of right valve; 9, exterior of left valve. Specimens from the Big House Chalk in Travis County, Texas (sample E-1).

10-12 *Diversipellis bicornis rectangula* Hazel, n. subsp.

10, exterior of left valve (holotype); 11, exterior of right valve; 12, dorsal view of carapace. Specimens from the lower Austin in Travis County, Texas (left valve from sample M-1, right valve and carapace from sample 2F-1).

13 *Isocythereis* aff. *I. austinensis* (Alexander)

13, exterior of left valve. Specimen from the "Lower Taylor" Marl in Delta County, Texas (sample 2A-1).

14-16 <u>Isocythereis</u> <u>austinensis</u> (Alexander)

14, exterior of left valve of a male; 15, exterior of right valve of a female; 16, dorsal view of a male carapace. Specimens from the "Middle Marl" in Dallas County, Texas (sample T-3).

17-18 <u>Isocythereis</u> <u>hadraina</u> <u>orchama</u> Hazel, n. subsp.

17, exterior of left valve (holotype); 18, exterior of right valve. Specimens from the "Middle Marl" in Dallas County, Texas (sample T-3).

25-26 <u>Isocythereis</u> <u>hadraina</u> <u>hadraina</u> (Paulson)

25, exterior of right valve; 26, exterior of left valve. Right valve from the "Upper Chalk" in Dallas County, Texas (sample O-1); left valve from the Big House Chalk in Travis County, Texas (sample B-10).

19-20 <u>Pterygocythereis</u> <u>compressa</u> (Paulson)

19, exterior of right valve; 20 exterior of left valve. Specimens from the Brownstown Marl of southwestern Arkansas (sample 2E-1).

21 <u>Pterygocythereis</u>? sp.

21, exterior of left valve. Specimen from the Eaglefordian shales in Travis County, Texas. This species is illustrated to show the morphologic similarity between it and species of <u>Pterygocythereis</u> and <u>Diversipellis</u>. It is possible that species of this type give rise to both these genera.

22-24 <u>Pterygocythereis</u> <u>burdittensis</u> (Paulson)

22, exterior of left valve; 23, exterior of right valve; 24, dorsal view of carapace. Specimens from the Big House Chalk in

Travis County, Texas (sample C-2).

27 *Pterygocythereis tokiana* (Israelsky)

27, exterior of left valve. Specimen from the Big House Chalk in Travis County, Texas (sample C-2).

28 *Pterygocythereis ponderosana* (Israelsky)

28, exterior of right valve. Specimen from the Dessau Chalk in Travis County, Texas (sample A-3).

29-30 *Pterygocythereis ingens* Hazel, n. sp.

29, dorsal view of carapace; 30, exterior of right valve (holotype). Specimens from the Big House Chalk in Williamson County, Texas (sample H-1).

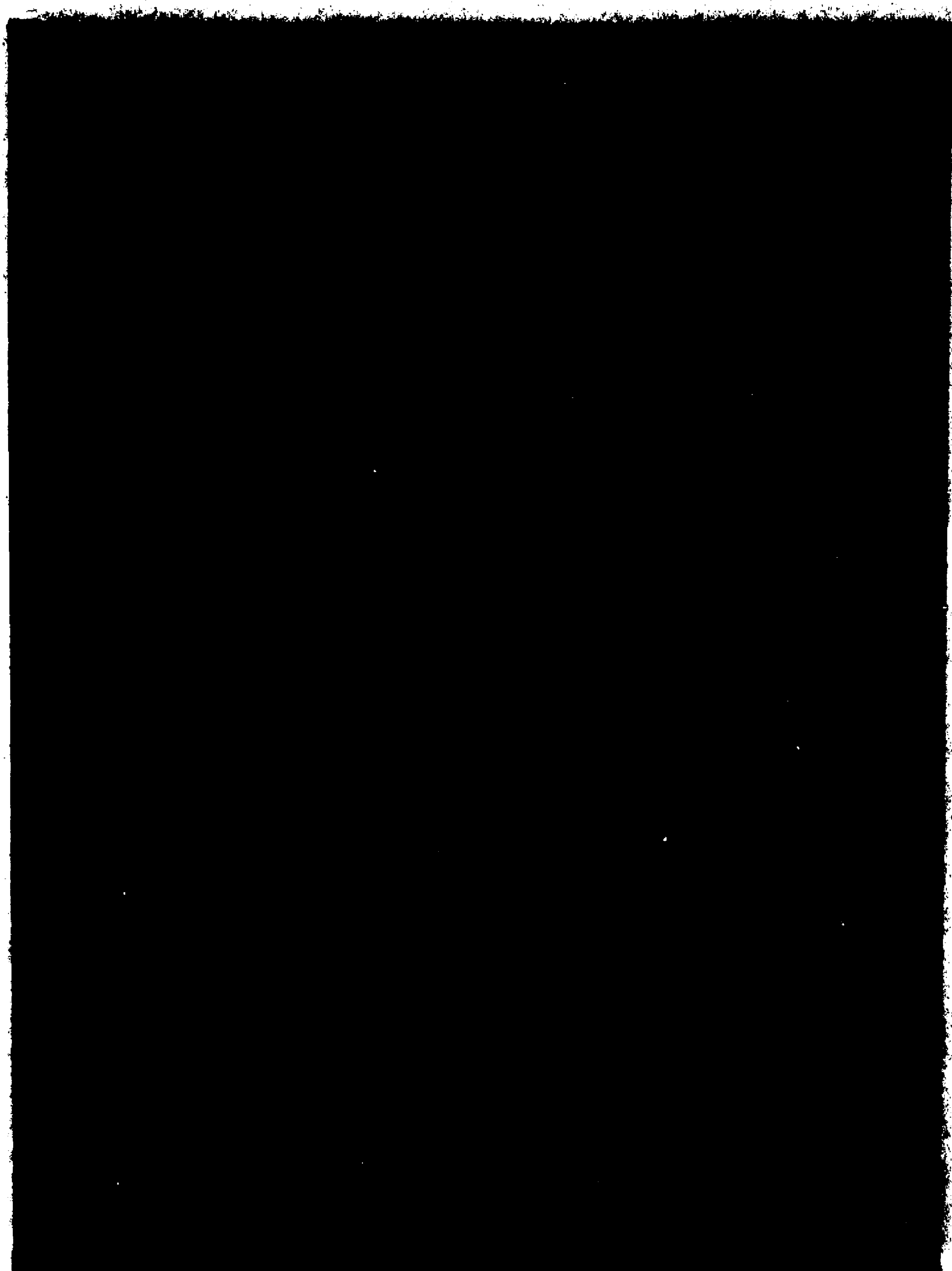

Plate II

PART II

INTRODUCTION

A satisfactory, formal zonation of the Austinian and Tayloran[1] stages in the Western Gulf region has never been made. Thus, though correlations within general limits have been known for many years, a finer correlation of the various facies from central Texas to Arkansas has never been realized.

This paper contains the findings of an investigation of the vertical and lateral distribution of cytheracean ostracodes within the upper Austinian and lower Tayloran deposits in the Northeast Texas Embayment area. The writer endeavors to show that this stratigraphic sequence can be cogently zoned using ostracodes and presents the resulting correlations (text fig. 13).

Samples from measured sections in the Austin and Taylor Groups in the Austin, Waco, and Dallas areas were collected by the writer in the spring, summer and fall of 1962. In addition slides and samples in the collections of Dr. H. V. Howe and the Louisiana State University Geology Museum were used extensively in the study. In all, the ostracodes from over 200 samples were identified.

The writer is indebted to Drs. A. H. Cheetham and W. A. van den Bold with whom many informative discussions have been held and who have critically read the manuscript and offered helpful suggestions. Thanks are due Dr. C. O. Durham for aid in locating outcrops, allowing the

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[1]The stage terminology of Murray (1961) is used herein though the writer is one of those . . ."who maintain that . . .(stage) properly belongs to the field of biostratigraphy" (ibid., p. 279).

writer use of unpublished materials and for helpful advice concerning Austin stratigraphy; Dr. H. V. Howe who allowed use of his extensive library and slide collections; Dr. H. V. Andersen, curator of the Louisiana State University Geology Museum, for use of sample and slide collections. Special thanks are due Mr. L. G. Nichols, assistant curator L. S. U. Geology Museum, who photographed the ostracodes.

The study was supported by a fellowship from the Humble Oil and Refining Company.

LITHOLOGIC UNITS IN CENTRAL AND NORTH-CENTRAL TEXAS

Introduction.- In the type area of the Austin Group, Travis County, the group is over 400 feet thick. The lower Austin, that part below the Dessau Chalk, is nearly 300 feet thick and the upper Austin, consisting of, in ascending order, the Dessau Chalk, Burditt Chalk Marl and Big House Chalk, is approximately 135 feet thick. In the Dallas area the Austin Group is some 600 feet thick and consists of the "Lower Chalk," "Middle Marl" and "Upper Chalk."

Though samples from the lower as well as the upper Austin were examined, only the more fossiliferous upper part of the group is considered in the zonation.

In the type area the lower Taylor, as considered herein, consists of the "Lower Taylor" Marl and the overlying Pecan Gap Chalk. Here the lower Taylor is approximately 200 feet thick. Northeastward, in the Dallas area, with the addition of the Wolfe City Sand below the Pecan Gap, the lower Taylor sequence is over 600 feet thick.

Dessau Chalk.- This formation, named by Durham (1955), varies in thickness from 85 feet in Travis County to over 200 feet in Bell County. In the former area the lower 10 feet is a glauconitic, fragmental limestone and the upper 75 feet is chalk with marl interbeds. The fragmental portion is lenticular, pinching out to the south on the San Marcos arch and to the north in Bell County, Durham (1957 ms).

Burditt Chalk Marl.- This unit was named by Adkins (1933). As restricted by Durham (1957 ms), it consists of chalk marls, marls and clay marls and varies from about 30 feet thick at Austin to over 80 in Bell

County. The contact with the overlying Big House Chalk is transitional.

Big House Chalk.- Named by Durham (1957 ms), this unit includes the uppermost chalks of the Austin Group in central Texas. In the Austin area it is a chalk with marl and clay-marl interbeds. It varies in thickness from 20 feet at Austin to over 40 feet at the type locality on the San Gabriel River in Williamson County. Here it "includes over twenty feet of white chalk overlain by twenty feet of chalky marl transitional to lower Taylor marls" (Durham, 1957 ms, p. 17).

The name is technically a nomen nudum, for Durham's 1957 manuscript was to have been published, in part, as a section of the Cretaceous Symposium of the XX International Congress at Mexico City, but is now apparently not to be printed. However, the unit is recognizable and the name has appeared in print in Murray (1961), Gimbrede (1962) and Young (1962).

"Lower Taylor" Marl.- This unnamed unit varies from a brown, unctuous clay, when weathered, to a massive, uniformly bedded or blocky dark marl, when fresh. Thicknesses vary fromapproximately 170 feet at Austin to over 500 at Dallas. South of Austin in Bexar County the entire "Lower Taylor" and most of the upper Austin are missing as the Pecan Gap Chalk rests on lower Dessau. The unit rests disconformably on the Austin in Travis County but is transitional with the Big House in Williamson County. It disconformably overlies the Austin in the Waco area, but the contact is again transitional at Dallas. There is a discontinuity surface developed within the unit in northeast Texas (Paulson, 1960 ms).

Wolfe City Sand.- This formation transitionally overlies the "Lower Taylor" and extends as far south as Bell County where it was originally called the Durango Sand. In central Texas it ranges in thickness from 65 to 100 feet, and wedges out near Zabcikville in Bell

County (Durham, 1957 ms, fig. 10). It is a calcareous, argillaceous sand, marly in the upper portion; in some areas it is a sandy clay. In northeast and northcentral Texas the formation directly underlies the Pecan Gap, but in Falls and Bell Counties it is separated from the chalks of the Pecan Gap by beds of "Lower Taylor" lithology (Durham 1957 ms).

Pecan Gap Chalk.- This formation is a clay-marl or marly chalk, bluish gray when fresh and white to yellow when weathered. Thicknesses vary from 40 feet at Austin to over 100 farther north. In central and northeast Texas the unit rests on the Wolfe City Sand or "Lower Taylor" clays and marls. This contact has been considered to be disconformable in most areas of central and northeast Texas (Ellisor and Teagle, 1934; Rouse, 1944; Adkins, 1933; Stephenson et al., 1942). Frizzell and Anderson (1950) documented several diastems within this unit in Travis County and suggested that the thinning of the Pecan Gap in that area may be the result of these hiatuses.

The chalk at Dallas at present has no formal designation. Though the term Dallas Limestone was used for the chalk in central Texas by Hill (1887), Shumard (1860) had previously designated the unit Austin Limestone. At present the three principal divisions of the Dallas Petroleum Geologists (1941, p. 42) are in general use; these are the "Lower Chalk" 200 feet thick, "Middle Marl" 220 feet thick and "Upper Chalk" 180 feet thick.

The lithostratigraphy of the upper two units was studied by Smith (1955 ms) who demonstrated that the "Upper Chalk" contains two major lithologic units. The uppermost unit is a chalky marl 60-70 feet thick in which clay content increases and carbonate decreases upwards until the unit grades into "Lower Taylor" Marl. Below the upper unit is approximately 150 feet of hard chalk with chalk-marl interbeds. The underlying "Middle Marl" is a distinctive unit of marl with chalk interbeds.

The lithologic units above are those from which the writer sampled in detail or had access to numerous samples collected therefrom. Correlations are made into northeast Texas and Arkansas and recent discussions of the lithic units of these areas can be found in Paulson (1960 ms), Thorsen (1959 ms), Collins (1960 ms) and Murray (1961) and references therein.

BIOSTRATIGRAPHY

General.- Paleontologic correlations in the Austinian and Tayloran of the Western Gulf have been based primarily on pelecypods or benthonic foraminifers.

Zonation attempts with pelecypods, except on a very general basis, have not proved successful because occurrences of these species in the Austinian and Tayloran tend to be in biostromes. Correlations between widely separated localities based on such ecologically controlled, possibly repetitive, epiboles can be spurious. Most of the benthonic foraminifers have ranges too long within the chalks and marls for developing a zonation, though several shorter-ranging species are useful (Gimbrede, 1960 ms). At the time of this writing a detailed zonation using ammonites is forthcoming (K. Young, personal communication, 1962). Most early biostratigraphic studies were hampered by lack of a sound stratigraphic grid.

In central and north-central Texas exposures of the Austin Group and to some extent of the Taylor Group lie within the Balcones Fault Zone, and outcrop thicknesses seldom exceed 100 feet. Difficulty in tracing beds along strike prevented establishment of a satisfactory stratigraphic grid and precluded detailed biostratigraphic studies. Durham (1957 ms) provided such a grid for the Austin Group in a detailed, bed-by-bed analysis in central and north-central Texas. His work is of primary importance in the present study.

That ostracodes have considerable merit as biostratigraphic tools in the American Cretaceous was first stressed by Alexander (1929) in his comprehensive treatment of the Texas Cretaceous Ostracoda. Lozo (1943, p. 1079) in a study of the Fredricksburg-Washita boundary re-emphasized Alexander's thesis by stating, "The Ostracoda are not affected so greatly by the bottom-sediment factor as are the Foraminifera and are thus more useful as chronologic indicators, at least in the stratigraphic section discussed." However, in general, ostracodes have been little used in biostratigraphy and have played a secondary role to other groups. This seems to be related more to the small number of studies than to either the scarcity of ostracodes or their alleged nonutility in biostratigraphy (see Teichert, 1958, fig. 1).

That portion of the Austin and Taylor Groups in central Texas from the lower part of the Dessau Chalk to a level within the Pecan Gap Chalk can be divided into two biostratigraphic zones based on ostracodes, a lower one, herein named the *Pterygocythereis burditteasis* zone, and an upper one, herein named the *Bradleya plummeri* zone.

In this zonation only ostracodes of the superfamily Cytheracea were used. This taxon includes most post-Paleozoic ostracodes. Its species are usually distinctly ornamented, thus relatively easily identifiable, and short-ranging, thus useful in biostratigraphy. In contrast, representatives of the Platycopida and such podocopid groups as the Bairdiacea, Pontocypridae and Paracypridae, which occur in some abundance in the Austinian and Tayloran, are, in general, long-ranging and not easily identified and therefore of limited use in biostratigraphy.

Zonal occurrence and restriction.- Tables I and II give numerical values to the constancy of occurrence and degree of restriction of the various species and subspecies of Cytheracea to the two zones. Constancy is calculated as the fraction (in tenths) of the samples of a zone in which a certain taxon was found. Restriction is the zonal reliability of a taxon (also given in tenths) and is calculated by comparing the constancy of a taxon for a zone to its constancy for the zone above and/or below ($R = \frac{C_1 \times 10}{C_1 + C_2 + C_3}$). For example, if a taxon occurs in 40 of 50 samples from a zone it would have a constancy of eight since it occurs in 80 per cent of the samples. If it also occurs in 10 of 50 samples in the zone above (constancy of 2) and in none of the samples from the zone below, it would have a restriction of eight ($R = \frac{8 \times 10}{8 + 2 + 0} = 8$). Cheetham (1963) and Newell *et al*. (1959) have used similar methods in paleoecological and ecological studies.

The taxa are listed in the tables in order of decreasing restriction; thus the index and more diagnostic guide fossils appear at the top of the list. But utility depends upon their constancy as well as restriction. Only those species with a constancy greater than two are shown.

In calculating restriction the portion of the Austinian below the *Pterygocythereis burdittensis* zone was considered to be a subjacent "zone." A portion of the Tayloran above the *Bradleya plummeri* zone appears to be a sound biostratigraphic zone. Eighty samples from the subjacent "zone," 64 from the *Pterygocythereis burdittensis* zone, 43 from the *Bradleya plummeri* zone and 30 from the superjacent zone were used in the calculation of re ction.

Pterygocythereis burdittensis *Zone*.- The fauna of this zone is characterized by *P. burdittensis* (Paulson), which is restricted to the zone, and other species or subspecies given in Table 1 which have high constancy and high restriction for the zone.

Several species have low constancy in the zone as a whole but have high restriction and are important locally. These include

TABLE I-- PTERYGOCYTHEREIS BURDITTENSIS ZONE

GEOGRAPHIC OCCURRENCE: Traceable at least from central Texas into southwestern Arkansas

STRATIGRAPHIC OCCURRENCE: Comprised of all or part of the following lithostratigraphic units: Dessau Chalk (part), Burditt Chalk Marl, Big House Chalk, "Lower Taylor" Marl (part), "Upper Chalk" at Dallas, Brownstown Marl (part), and Gober Chalk

CHARACTERISTIC SPECIES:	RESTRICTION:	CONSTANCY:
Pterygocythereis burdittensis	10	5
Diversipellis bicornis bicornis	8	8
Phacorhabdotus simplex	8	2
Brachycythere acuminata	8	4
Isocythereis hadraina hadraina	7	7
Asciocythere? austinensis	7	6
Haplocytheridea grangerensis	6	6
Brachycythere pyriformis	6	3
Cytheropteron furcalatum	6	3
Krithe cushmani	5	6
Brachycythere "sphenoides"	5	6
"Cythereis" hannai	5	3
Pterygocythereis tokiana	5	5
"Cythereis" caudata	5	2
Brachycythere triangulacornis	4	4
Veenia ozanana	4	7
Cythereis dallasensis	4	6
Haplocytheridea plummeri	3	2

Pterygocythereis ingens Hazel (restriction of 8) in central Texas, Trachyleberidea anocula (Paulson) (restriction 8) in the Dallas area, Costa redunca Hazel (restriction 7) and Henryhowella spoori (Israelsky) (restriction 9) in the Arkansas area.

Table I shows that this zone has occurring within it several species which have high constancy and restriction for the zone, but only one abundant species which is restricted to it. Thus the zone is characterized by a distinctive assemblage and essentially is an assemblage- or cenozone. However, the writer feels that where fine correlations within a region are needed, a zone defined strictly on an assemblage leaves the boundaries in a too indefinite state. This is particularly true in areas where there are no convenient, regional, temporally important hiatuses. Therefore, the writer has tied the zonal boundaries closely to the ranges of species or groups of species. This results in a type of assemblage zone, one in which the arbitrary boundaries and biosomal aspect of that type of zone have been minimized.

The base of the Pterygocythereis burdittensis zone is marked by the first appearance of P. burdittensis, Isocythereis hadraina hadraina and Diversipellis bicornis bicornis and by the last appearance of Isocythereis austinensis, I. hadraina orchama and Diversipellis bicornis rectangula.

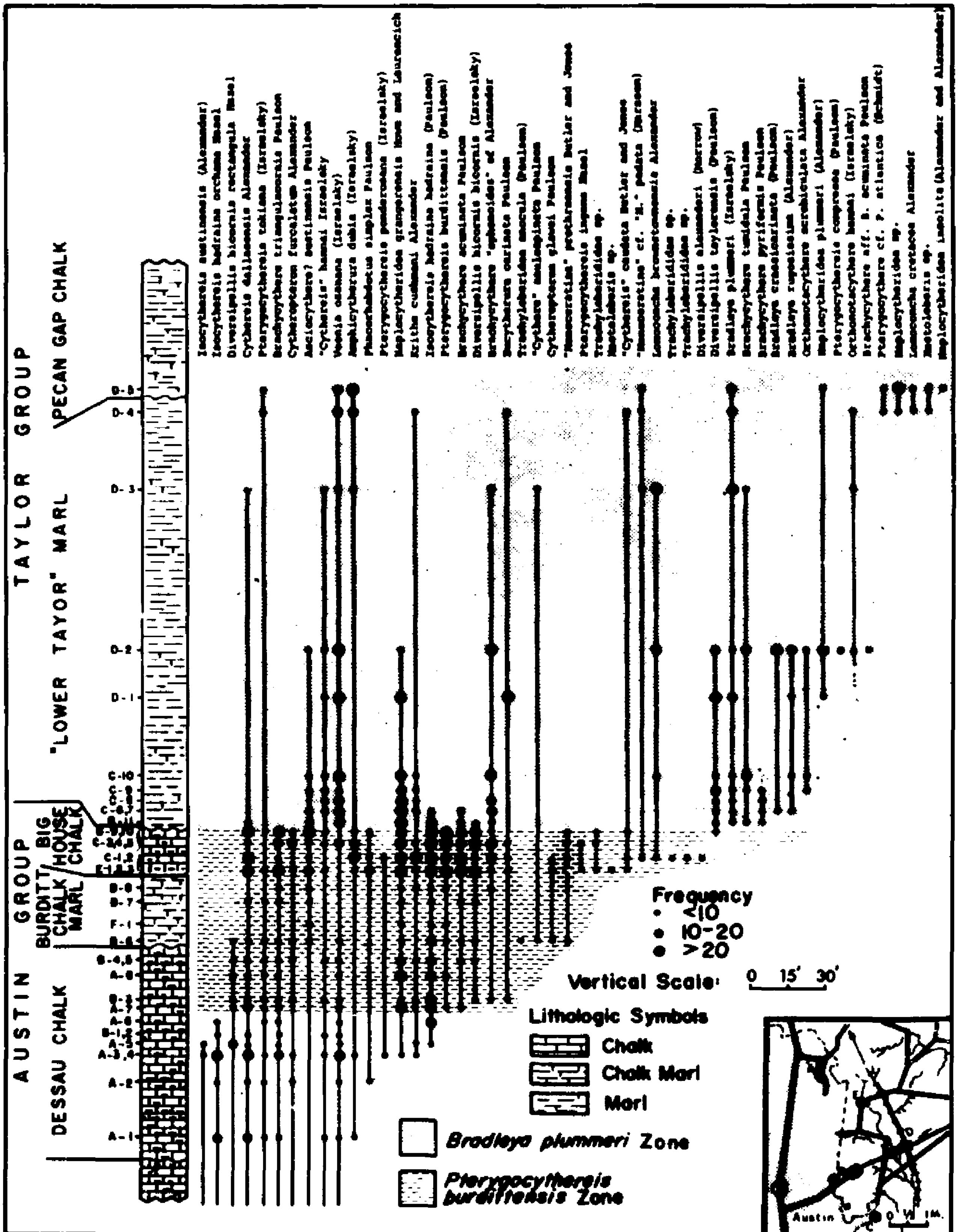
The Austinian below the Pterygocythereis burdittensis zone, in general, does not yield good ostracode samples. This is partly due to the lithology, chalks in central and north-central Texas and sands in Arkansas and portions of northeast Texas. Only a few taxa tend to be diagnostic for that part of the section. These include Isocythereis austinensis, I. hadraina orchama, Diversipellis bicornis rectangula and locally Vennia bonhamensis.

Pterygocythereis burdittensis seems to be an immigrant species into central and northeast Texas, and its abundance in central Texas indicates introduction from the south. It appears to have spread so rapidly over the western part of the basin that its lowest occurrence is probably nearly synchronous. Teichert (1958) among others has stressed that, barring impassable barriers, the dispersal of an organism introduced into an area can be geologically instantaneous. In the absence of Isocythereis austinensis and Pterygocythereis burdittensis from a section, a boundary determination based on Isocythereis hadraina hadraina and/or Diversipellis bicornis bicornis will not be as sharp as if the former two taxa were present because of the morphologic overlap of the latter two with their progenitors.

Ostracodes increase in numbers of species and individuals so that they are quite abundant in the upper part of the zone in most areas. The top of the zone is marked by the disappearance of Pterygocythereis burdittensis, particularly in central Texas, but is drawn more effectively on the initial appearance of certain species of the Bradleya plummeri zone.

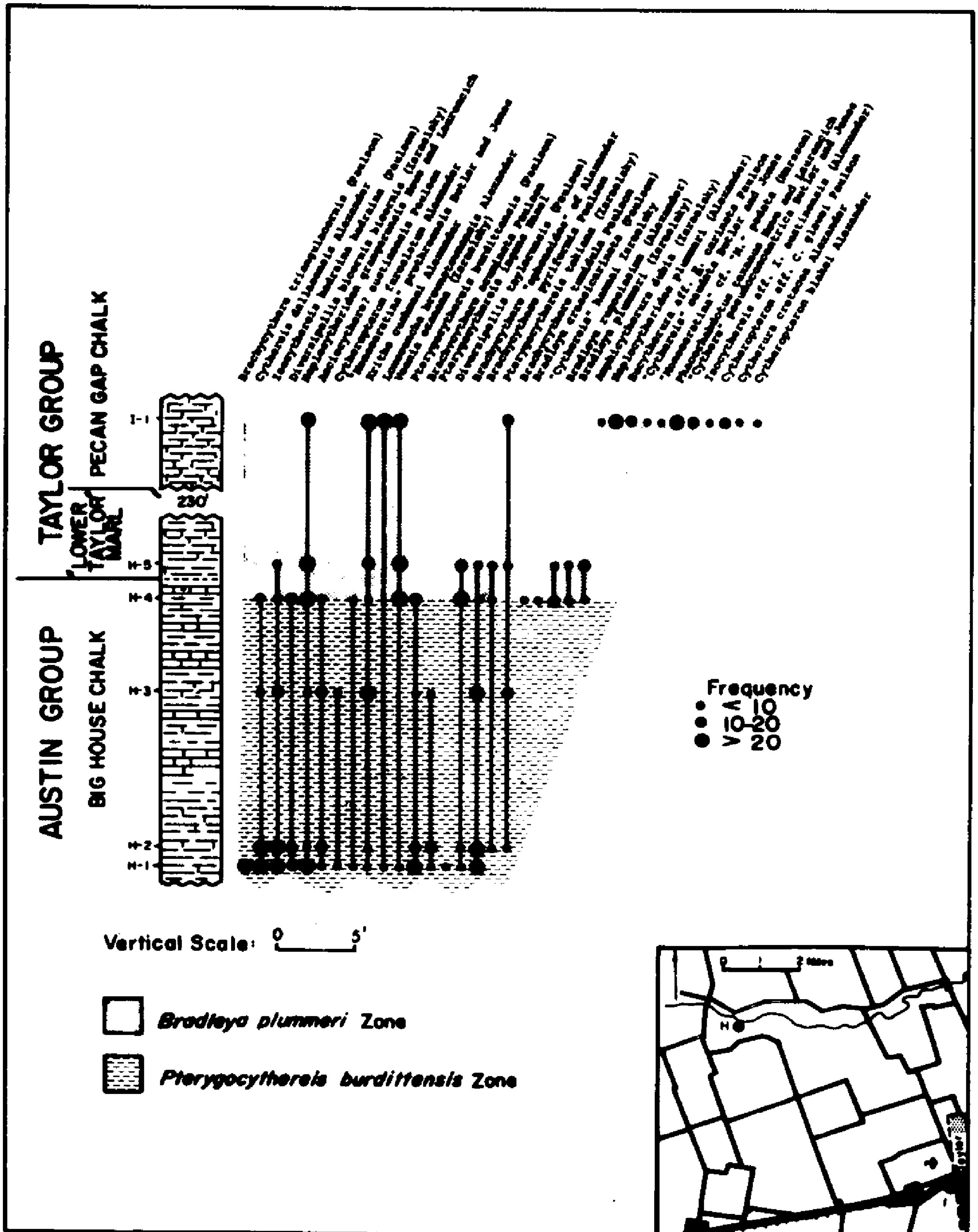
In Travis County (text fig. 1) the base of the Pterygocythereis burdittensis zone falls some 65 feet above the base of the Dessau Chalk and 25 feet below the Burditt Chalk Marl contact. This is nearly midway between the Gryphaea aucella and Exogyra tigrina biostromes of Stephenson (1937). The top of the zone is coincident with the disconformable Big House Chalk-"Lower Taylor" Marl contact. Here the zone is approximately 75 feet thick.

In Dallas County (text fig. 6) the zone thickens to over 200 feet and to nearly 400 feet in the Fannin County area, but thins eastward in Arkansas to approximately 150 feet in the vicinity of Ben Lomond, Text-Fig. 1 -- Ranges and occurrences of cytheracean ostracodes in the Austin, Texas, area. Individual samples of the thin but heavily collected Big House Chalk are combined by locality and do not necessarily indicate exact position in sequence. Other samples are combined on this and succeeding figures but their position in sequence is correct. On this and succeeding figures the ranges of successional subspecies are shown as overlapping in order to give the ranges of the morphologic types which characterize the subspecies, <u>not</u> to indicate contemporaneous subspecies.


AUSTIN GROUP
TAYLOR GROUP
DESSAU CHALK
BURDITT CHALK MARL
BIG HOUSE CHALK
"LOWER TAYOR" MARL
PECAN GAP CHALK
Frequency
<10
10-20
>20
Vertical Scale: 0 15' 30'
Lithologic Symbols
Chalk
Chalk Marl
Marl
Bradleya plummeri Zone
Pterygocytheris burdittensis Zone
Austin

Text-Fig. 1

Text-Fig. 2 -- Ranges and occurrences of cytheracean ostracodes at two localities in Williamson County, Texas.


AUSTIN GROUP
BIG HOUSE CHALK
TAYLOR GROUP
LOWER TAYLOR MARL
PECAN GAP CHALK
H-1
H-2
H-3
H-4
H-5
I-1
230'
Frequency
< 10
10-20
> 20
Vertical Scale: 0 5'
Bradleya plummeri Zone
Pterygocythereis burditensis Zone
H
0 1 2 Miles
Taylor

Text-Fig. 2

Sevier, County (text fig. 9).

There is some change in biofacies from central Texas to Arkansas and some of the typical species of the assemblage in central Texas, including Pterygocythereis burdittensis, do not occur in Arkansas.

Bradleya plummeri Zone.- Table II shows that while this zone has four restricted species, three of these have low constancy and there are no guide fossils with high constancy. Thus, the assemblage as a whole is not as distinctive as that of the Pterygocythereis burdittensis zone. The most important element of the zone is Bradleya plummeri which not only has a restriction of 10, but also a constancy of 8 and occurs from Arkansas to central Texas. While the Pterygocythereis burdittensis zone is a type of assemblage-zone, the Bradleya plummeri zone is more of a range-zone or acrozone.

The base of the zone is marked by the last appearance of Pterygocythereis burdittensis and other species of that zone, but primarily by the appearance of Bradleya plummeri, B. rugosissima (Alexander) and B. crassicarinata (Paulson). These three species show no close kinship to any of the species of the preceding zone and seem to be immigrants, apparently not from eastern areas since they were not recorded by Swain (1948, 1952), Brown (1957, 1958) or Shaver (1958). Their appearance probably records the elimination of a physical barrier or development of a favorable environment or both.

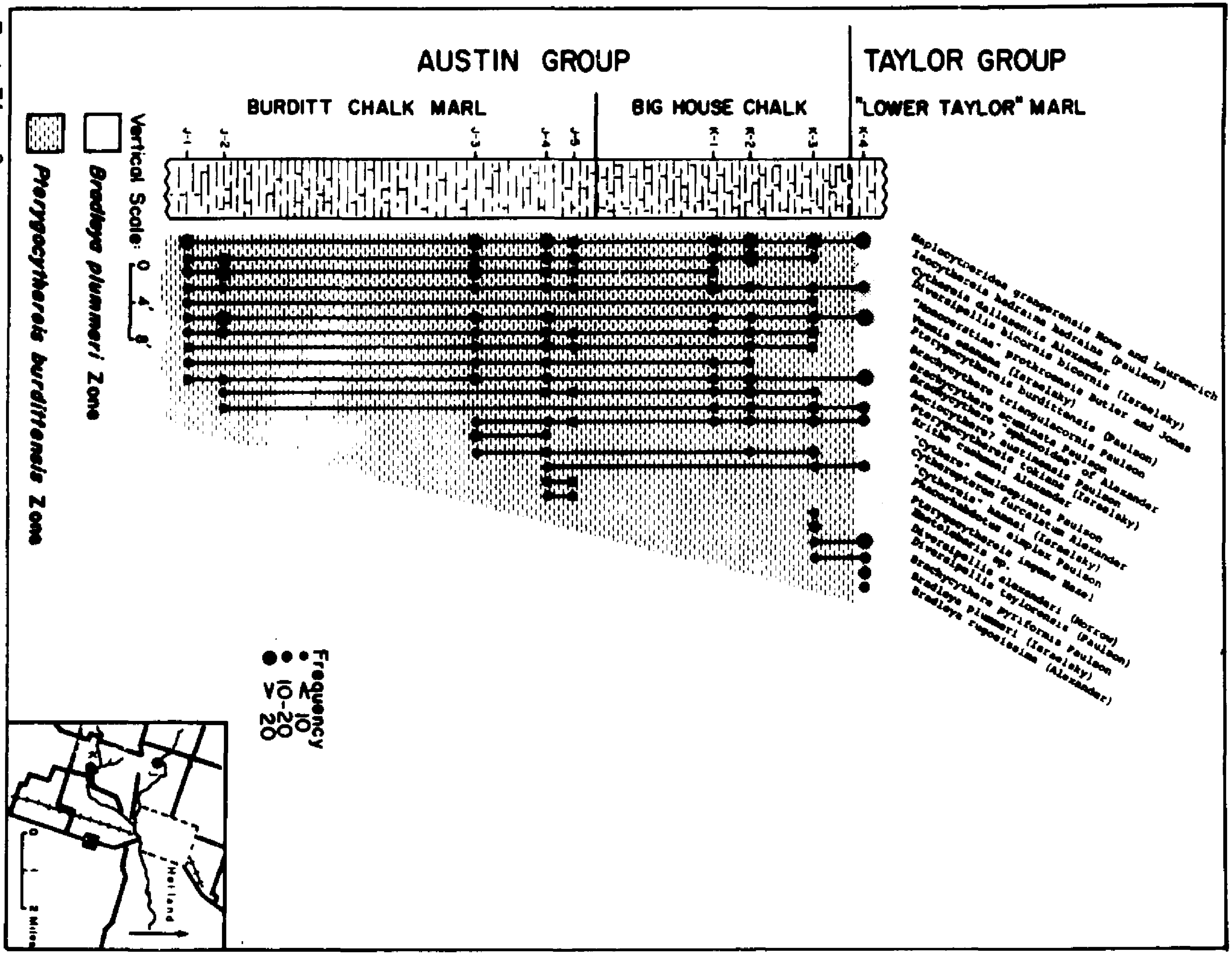
Indigenous as well as immigrant taxa are affected by any such changes in the milieu. New forms may develop which are better equipped to deal with the changes. Many of the indigenous taxa may well be able to cope with the new situation; however, immigrant, better adapted species may compete for the same niches and, generally, will eliminate the competition, though the adaptive advantage of the new arrivals may be

TABLE II-- BRADLEYA PLUMMERI ZONE

GEOGRAPHIC OCCURRENCE:	Traceable at least from central Texas into southwestern Arkansas
STRATIGRAPHIC OCCURRENCE:	Comprised of all or part of the following lithostratigraphic units: "Lower Taylor" Marl (part), Pecan Gap Chalk (part), Wolfe City Sand and Ozan Formation (part)

CHARACTERISTIC SPECIES:	RESTRICTION:	CONSTANCY:
Bradleya plummeri..............	10..........	8
Bradleya rugosissima...........	10..........	3
Haplocytheridea insolita.......	10..........	2
Bradleya crassicarinata........	10..........	2
Brachycythere tumidula.........	9..........	2
Diversipellis taylorensis......	8..........	4
Loxoconcha brownstownensis.....	6..........	2
Amphicytherura dubia...........	6..........	5
Cytheropteron blakei...........	6..........	2
Haplocytheridea plummeri.......	5..........	6
Veenia ozanana.................	5..........	8
Brachycythere "sphenoides".....	5..........	5
"Monoceratina" cf. "M." pedata.	4..........	3
Krithe cushmani................	4..........	6
Haplocytheridea grangerensis...	3..........	4
Cythereis dallasensis..........	3..........	2
Isocythereis hadraina hadraina.	2..........	2

Text-Fig. 3 -- Ranges and occurrences of cytheracean ostracodes at two localities in Bell County, Texas.


AUSTIN GROUP
TAYLOR GROUP
BURDITT CHALK MARL
BIG HOUSE CHALK
"LOWER TAYLOR" MARL
J-1
J-2
J-3
J-4
J-5
K-1
K-2
K-3
K-4
Haplocytheridea grangerensis Howe and Laurencich
Cythereis dallasensis Alexander
Diversipollis bicornis bicornis (Israelsky)
Pterygocythereis burdittensis (Paulson)
Brachycythere triangulacornis Paulson
Brachycythere acuminata Paulson
Kritha cushmani Alexander
Cytheropteron furcalatum Alexander
Pterygocythereis simplex Paulson
Diversipollis alexanderi (Morrow)
Brachycythere pyriformis Paulson
Bradleya plummeri (Israelsky)
Bradleya rugosissima (Alexander)
Vertical Scale: 0 4' 8'
Bradleya plummeri Zone
Pterygocythereis burdittensis Zone
Frequency
≤ 10
10-20
≥ 20
Holland
2 Miles

Text-Fig. 3

slight and the competitors may live together for awhile. Several species, Brachycythere acuminata, B. triangulacornia, Costa redunca and Diversipellis bicornis bicornis, of the Pterygocythereis burdittensis zone range into the lowermost part of the Bradleya plummeri zone but no higher.

At first glance it appears that Bradleya plummeri is controlled tightly by edaphic conditions for it appears in the Travis County area in the "Lower Taylor" clays just above the disconformable contact with the Big House Chalk. However, this is not the case for the species appears just below the top of the Big House at locality H in Williamson County (text fig. 2). At this locality the Big House is transitional with the "Lower Taylor" and in the lowest sample which carries B. plummeri the faunas of the two zones are quite mixed.[2] Further, in northeast Texas, the species first appears within the "Lower Taylor" marls 150 feet above the base.

The upper limit of the zone is drawn at the last appearance of B. plummeri and, in some places, the last appearance of Haplocytheridea insolita (Alexander and Alexander) and the first appearance of Phacorhabdotus texanus Howe and Laurencich.

In Travis County the zone is over 150 feet thick, the lower boundary falling at the Big House-"Lower Taylor" contact and the upper within the Pecan Gap Chalk (text fig. 1). The zone thickens northward reaching upwards of 650 feet in the Dallas area and then thins to 70 feet in southwestern Arkansas (text fig. 9).

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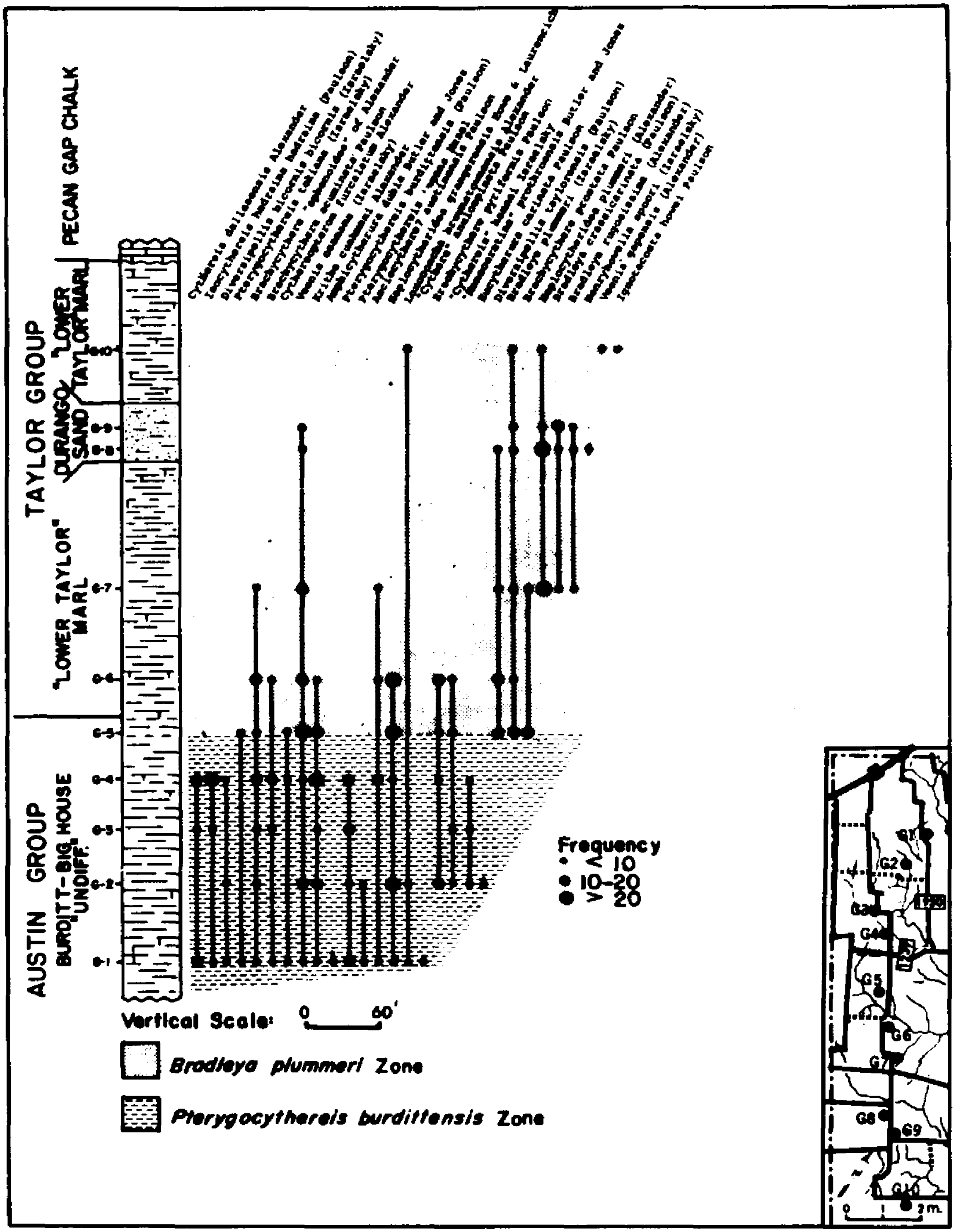
[2]Here the one foot of chalk between the first appearance of Bradleya plummeri and the base of the "Lower Taylor" may closely approximate the amount of chalk removed in Travis County.

Text- Fig. 4 -- Ranges and occurrences of cytheracean ostracodes in western Falls County, Texas.


AUSTIN GROUP
BURDITT-BIG HOUSE "UNDIFF."
TAYLOR GROUP
"LOWER TAYLOR" MARL
DURANGO SAND
"LOWER TAYLOR MARL
PECAN GAP CHALK
Vertical Scale: 0 60'
Bradleya plummeri Zone
Pterygocythereis burdittensis Zone
Frequency
< 10
10-20
> 20
G1
G2
G3
G4
G5
G6
G7
G8
G9
G10
0 1 2m.

Text-Fig. 4

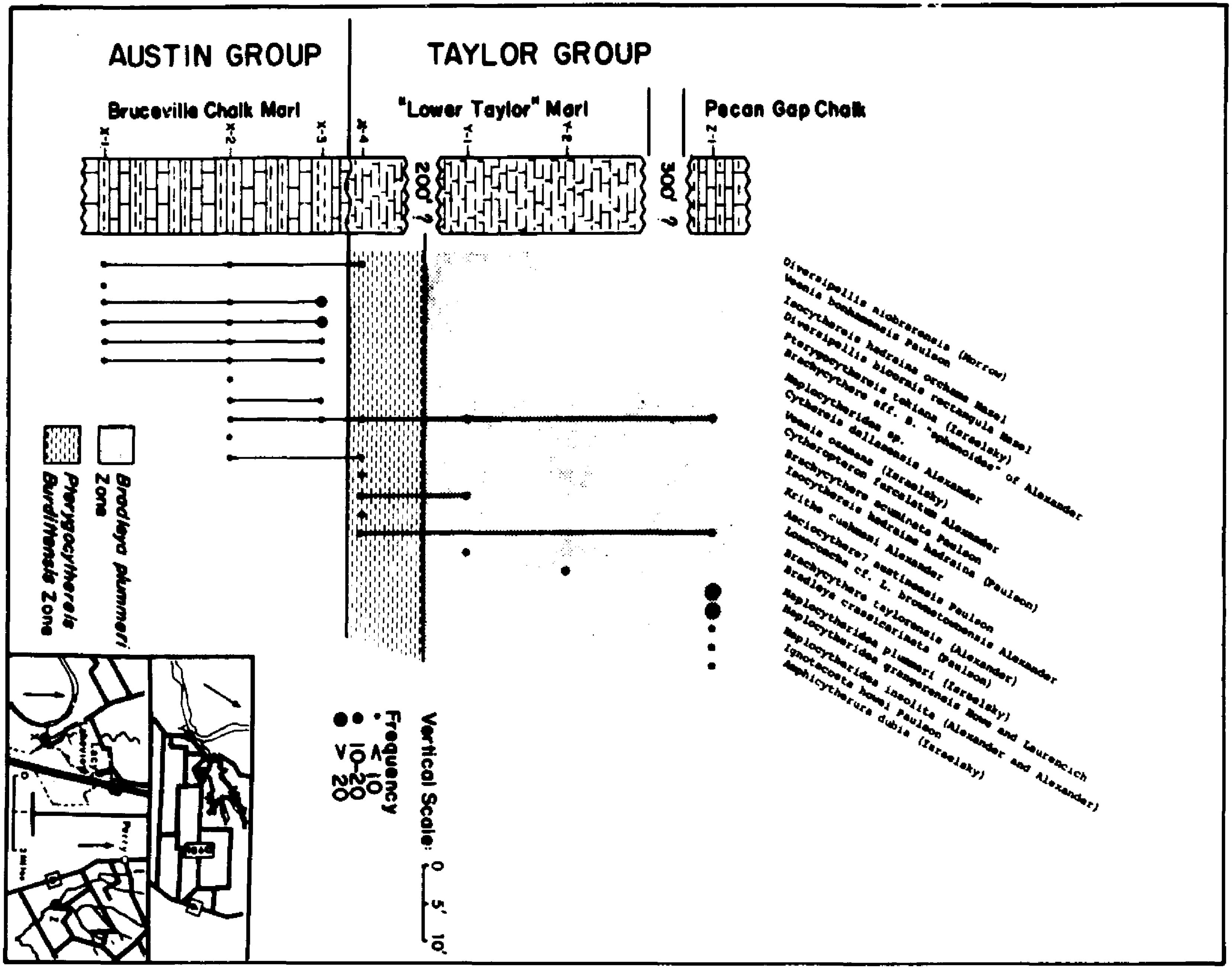
CORRELATION

Previous interpretations.- Stephenson (1929, 1937) documented the unconformity of greatest hiatus in the Austin and Taylor sequence. He was able to show that there is truncation in the Waco area where beds of "Lower Taylor" lithology lie upon lower Austin units -- his Inoceramus undulatoplicatus beds and Durham's (1957 ms) Bruceville Marl. Stephenson interpreted this disconformity as the same as the one at Austin between the Big House and "Lower Taylor," and thereby pictured progressive truncation northward from Austin to Waco, the upper Austin and part of the lower Austin being completely absent at Waco. This erosional surface was thought to be regional in extent by Stephenson and others and everywhere in the Western Gulf area to separate the Austin and its equivalents from the Taylor and its equivalents (text fig. 10).

Durham (1957 ms) showed that there could not have been progressive truncation northward from Austin to Waco because, though the Austin-Taylor contact at both Austin and Waco is disconformable, there is a conformable relationship between the two units in intervening areas. He was able to demonstrate, by tracing individual beds and oyster biostromes, that the upper Austin units thicken and become marlier towards Waco. These horizons could not be traced directly into the area of maximum truncation because of faulting south of Waco. Durham believes that the upper Austin units continue to become more argillaceous northward and that the "Lower Taylor" chalky marls above the disconformity at Waco are facies of the upper Austin at Austin (also see Adkins, 1933, p. 450, 451). Durham proposed that the disconformity

Text-Fig. 5 -- Ranges and occurrences of cytheracean ostracodes in the area of maximum truncation of the lower Austin near Waco, McLennan County, Texas.

Text-Fig. 5



AUSTIN GROUP
TAYLOR GROUP
Bruceville Chalk Marl
"Lower Taylor" Marl
Pecan Gap Chalk
X-1
X-2
X-3
X-4
Y-1
Y-2
Z-1
200' ?
300' ?
Diversipellis niobrarensis (Morrow)
Veenia bonhamensis Paulson
Isocythereis hadreias orchama Hazel
Diversipellis bicornis rectangula Hazel
Pterygocythereis tokiana (Israelsky)
Brachycythere aff. B. "sphenoides" of Alexander
Haplocytheridea sp.
Cythereis dallasensis Alexander
Veenia ozanana (Israelsky)
Cytheropteron furcalatum Alexander
Brachycythere acuminata Paulson
Isocythereis hadreias hadreias (Paulson)
Krithe cushmani Alexander
Asciocythere? austinensis Paulson
Loxoconcha cf. L. browstownensis Alexander
Brachycythere taylorensis (Alexander)
Bradleya crassicarinata (Paulson)
Haplocytheridea plummeri (Israelsky)
Haplocytheridea grangerensis Howe and Laurencich
Haplocytheridea insolita (Alexander and Alexander)
Ignotacosta howei Paulson
Amphicytherura dubia (Israelsky)
Bradleya plummeri Zone
Pterygocythereis Burditensis Zone
Vertical Scale: 0 5' 10'
Frequency
< 10
10-20
> 20

between the Austin and Taylor at Waco be the same as that at the base of the Dessau at Austin (text fig. 11). He further postulated that the entire chalk sequence at Dallas is equivalent to the pre-Dessau at Austin.

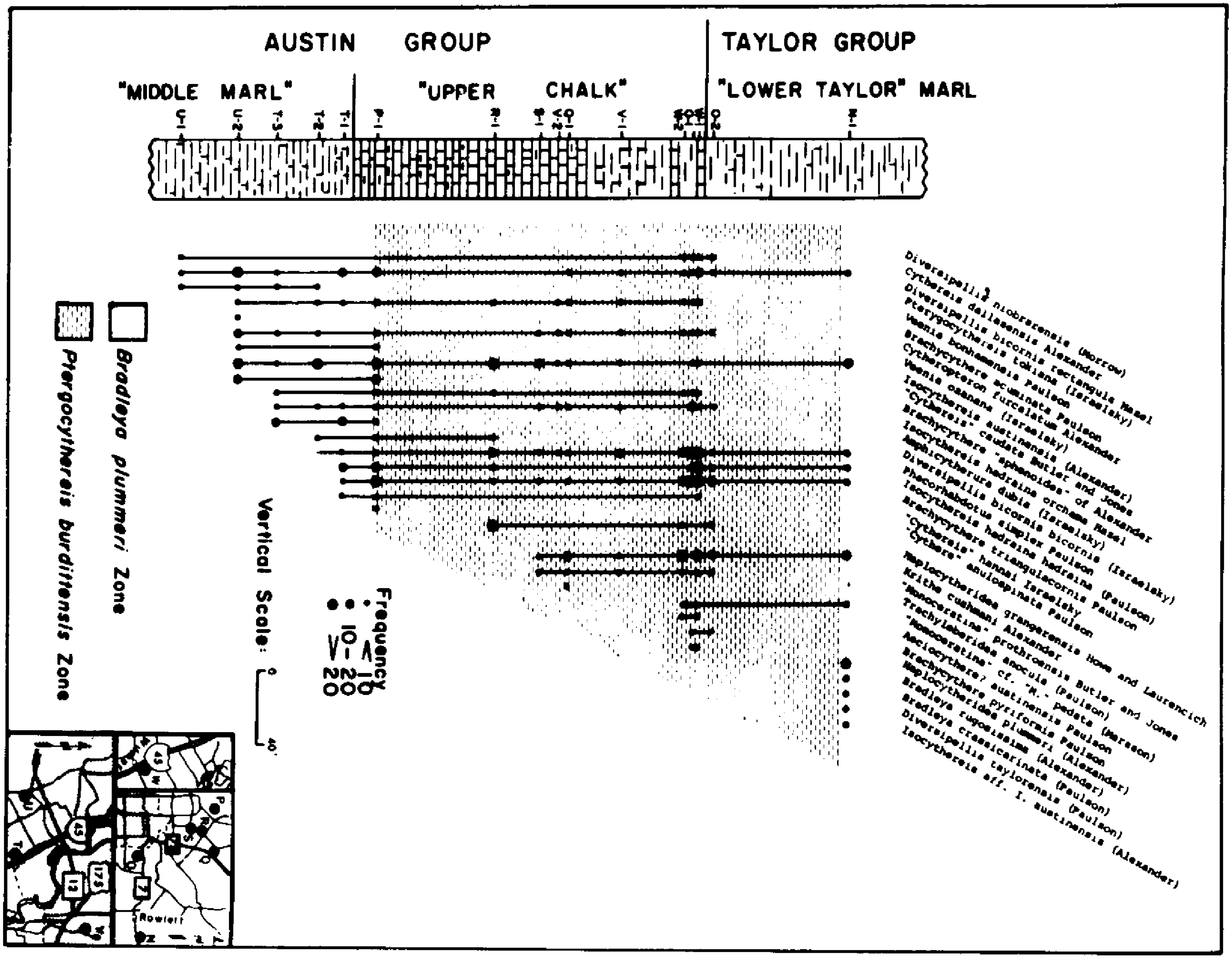
Stephenson (1937, p. 139) stated that the Austin-Taylor contact at Dallas is disconformable. However, Smith (1955 ms) demonstrated that the contact is transitional at Dallas but becomes erosional to the south in Ellis County (also see Overmeyer, 1953). Smith (1955 ms) and Stephenson (1937) showed truncation of the "Upper Chalk" through Ellis and Hill Counties and into McLennan County, where over 250 feet of Austin has been removed.

Stephenson et al. (1942) considered the Gober Chalk and Brownstown Marl of Arkansas to be the youngest units below the Austin-Taylor disconformity. He correlated the upper part of the Austin at Dallas with the lower Gober and considered the top of the Austin at Austin to be still older correlating it with the lower Brownstown of Texas. The top of the Blossom Sand was correlated with the base of the Burditt (text fig. 10).

Durham (1957 ms) correlated the Gober with the Big House, the Burditt with the upper Brownstown of Texas and the upper Blossom with the lower Dessau (text fig. 11). Paulson (1960 ms) substantiated these correlations and also correlated the top of the Austin at Dallas with the lowermost Burditt at Austin and with the upper Brownstown in northeast Texas. He considered the lowermost beds of the "Upper Chalk" at Dallas to be correlative with the upper Blossom and lower Dessau (text fig. 12).

Adkins (1933) showed the Ozan to be correlative with the Wolfe City-"Lower Taylor"-Gober sequence of northeast Texas. Stephenson et al. (1942) on the other hand considered the Ozan Formation of

Text-Fig. 6 -- Ranges and occurrences of cytheracean ostracodes in Dallas County, Texas.


AUSTIN GROUP
TAYLOR GROUP
"MIDDLE MARL"
"UPPER CHALK"
"LOWER TAYLOR" MARL
Diversipellis niobrarensis (Morrow)
Cythereis dallasensis Alexander
Diversipellis bicornis rectangula Hazel
Pterygocythereis tokiana (Israelsky)
Veenia bonhamensis Paulson
Brachycythere acuminata Paulson
Cytheropteron furcalatum Alexander
Veenia ozanana (Israelsky)
Isocythereis austinensis (Alexander)
"Cythereis" caudata Butler and Jones
Brachycythere "sphenoides" of Alexander
Isocythereis hadraina orchama Hazel
Amphicytherura dubia (Israelsky)
Diversipellis bicornis bicornis (Israelsky)
Phacorhabdotus simplex Paulson
Isocythereis hadraina hadraina (Paulson)
Brachycythere triangulacornis Paulson
"Cythereis" hannai Israelsky
"Cythere" anulospinata Paulson
Haplocytherides grangerensis Howe and Laurencich
Krithe cushmani Alexander
"Monoceratina" prothroensis Butler and Jones
Trachyleberides anocula (Paulson)
"Monoceratina" cf. "M." pedata (Marsson)
Asciocythere? austinensis Paulson
Brachycythere pyriformis Paulson
Haplocytherides plummeri (Alexander)
Bradleya rugosissima (Alexander)
Bradleya crassicarinata (Paulson)
Diversipellis taylorensis (Paulson)
Isocythereis aff. I. austinensis (Alexander)
Frequency
• < 10
● 10 - 20
● > 20
Vertical Scale: 0 — 40'
Bradleya plummeri Zone
Ptergocythereis burditensis Zone
Rowlett

Text-Fig. 6

southwestern Arkansas to be equivalent to the lower part of the Annona Chalk of Texas and with the lower part of the "Lower Taylor" elsewhere.

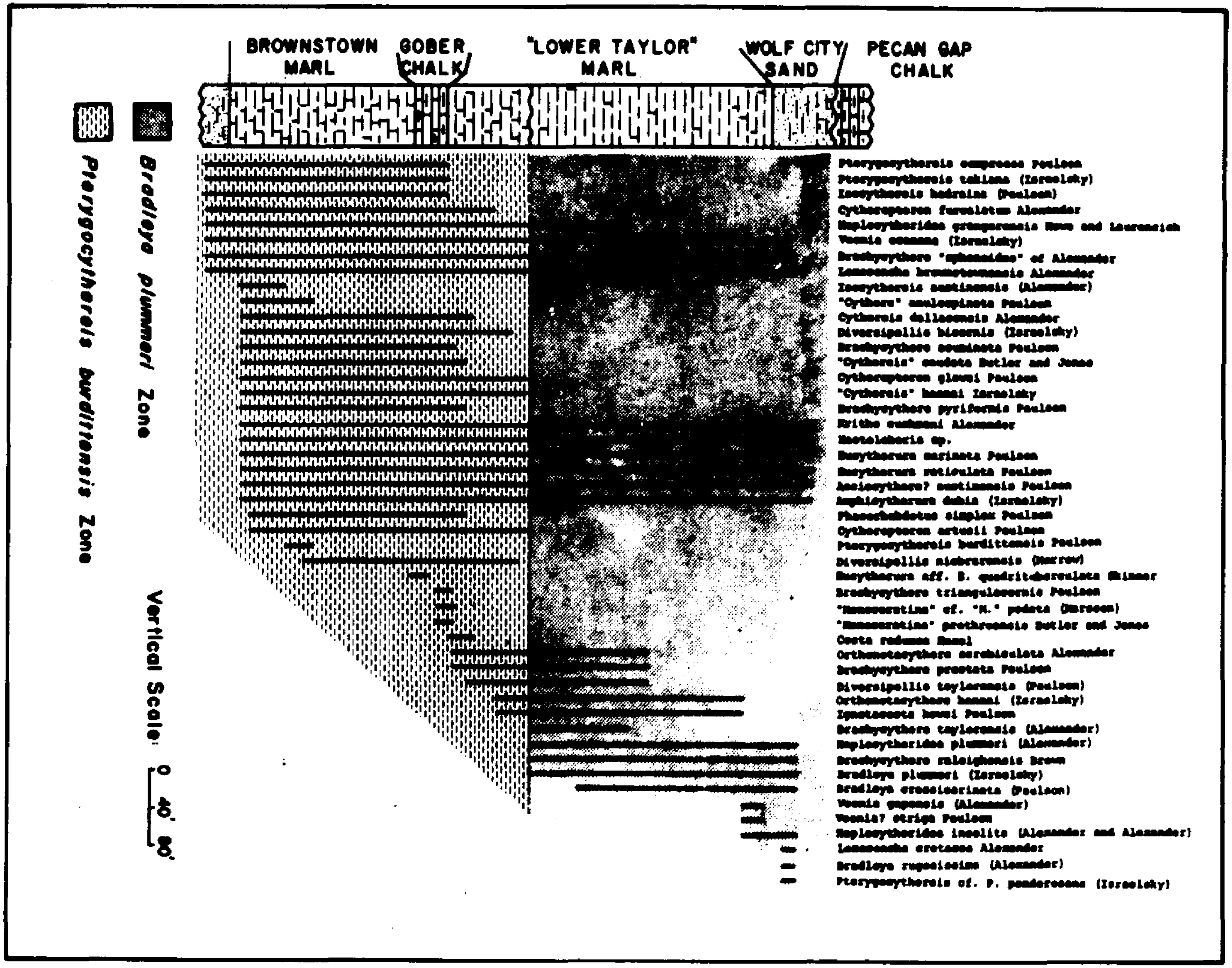
The Annona Chalk of Arkansas was shown by Stephen et al. (1942) as correlating with the upper part of the Annona of Texas, the Pecan Gap, Wolfe City and upper part of the "Lower Taylor." Rouse (1944) considered the Wolfe City to be correlative with the upper part of the Annona of Texas.

These by no means represent all of the correlation schemes that have been proposed for the Austinian and Tayloran formations in the Western Gulf; they are cited here to show the main differences of opinion that are contained in the major literature on this region.

Present interpretation.- In the area of Travis and Williamson Counties the base of the Pterygocythereis burdittensis zone falls in the upper part of the Dessau and the base of the Bradleya plummeri zone is coincident, or nearly so, with the Big House-"Lower Taylor" contact. The top of the Bradleya plummeri zone seems to fall in the upper part of the Pecan Gap Chalk. A sample (I-1, text fig. 2) from the upper Pecan Gap carries a fauna belonging to a superjacent zone. This locality is number 38 of Ellisor and Teagle (1934, pp. 1520, 1521) who state that the foraminiferal fauna here "belongs at the top of the Diploschiza cretacea zone" which in Williamson County would be the upper part of the Pecan Gap. This is also the type locality for Phacorhabdotus texanus which aids in marking the top of the Bradleya plummeri zone.

The Pterygocythereis burdittensis and Bradleya plummeri zones can be traced into Bell County (text fig. 3) and Falls County (text fig. 4). In Dallas County (text fig. 6) the lower boundary of the Pterygocythereis burdittensis zone is some 15 feet above the base of the "Middle Marl"-

Text-Fig. 7 -- Ranges of cytheracean ostracodes in northeast Texas. Data from Paulson (1960 ms, 1964).


BROWNSTOWN MARL
GOBER CHALK
"LOWER TAYLOR" MARL
WOLF CITY SAND
PECAN GAP CHALK
Bradleya plummeri Zone
Pterygocythereis burditensis Zone
Vertical Scale: 0 40' 80'
Pterygocythereis compressa Poulsen
Pterygocythereis tokiana (Israelsky)
Isocythereis hadraina (Poulsen)
Cytheropteron furcalatum Alexander
Haplocytheridea grungarensis Howe and Laurencich
Veenia ozanana (Israelsky)
Brachycythere "sphenoides" of Alexander
Loxoconcha brownstownensis Alexander
Isocythereis austinensis (Alexander)
"Cythere" aculeospinata Poulsen
Cythereis dallasensis Alexander
Diversipollis bicornis (Israelsky)
Brachycythere acuminata Poulsen
"Cythereis" caudata Butler and Jones
Cytheropteron glowi Poulsen
"Cythereis" hannai Israelsky
Brachycythere pyriformis Poulsen
Krithe cushmani Alexander
Xestoleberis sp.
Eucytherura carinata Poulsen
Eucytherura reticulata Poulsen
Asciocythere? austinensis Poulsen
Amphicytherura dubia (Israelsky)
Phacorhabdotus simplex Poulsen
Cytheropteron artusii Poulsen
Pterygocythereis burdittensis Poulsen
Diversipollis niobrarensis (Morrow)
Eucytherura aff. E. quadrituberculata Skinner
Brachycythere triangulacornis Poulsen
"Monoceratina" cf. "M." pedata (Marsson)
"Monoceratina" prothroensis Butler and Jones
Costa radiana Hazel
Orthonotacythere scrobiculata Alexander
Brachycythere prostata Poulsen
Diversipollis taylorensis (Poulsen)
Orthonotacythere hannai (Israelsky)
Ignotacosta hazeli Poulsen
Brachycythere taylorensis (Alexander)
Haplocytheridea plummeri (Alexander)
Brachycythere raleighensis Brown
Bradleya plummeri (Israelsky)
Bradleya crassicarinata (Poulsen)
Veenia gapensis (Alexander)
Veenia? striga Poulsen
Haplocytheridea insolita (Alexander and Alexander)
Loxoconcha cretacea Alexander
Bradleya rugosissima (Alexander)
Pterygocythereis cf. P. ponderosana (Israelsky)

Text-Fig. 7

"Upper Chalk" contact, and the base of the Bradleya plummeri zone is an estimated 80 feet above the transitional Austin-Taylor contact. The 165 foot sequence of "Upper Chalk" and 80 feet of "Lower Taylor" are correlative with the upper Dessau, Burditt and Big House of central Texas.

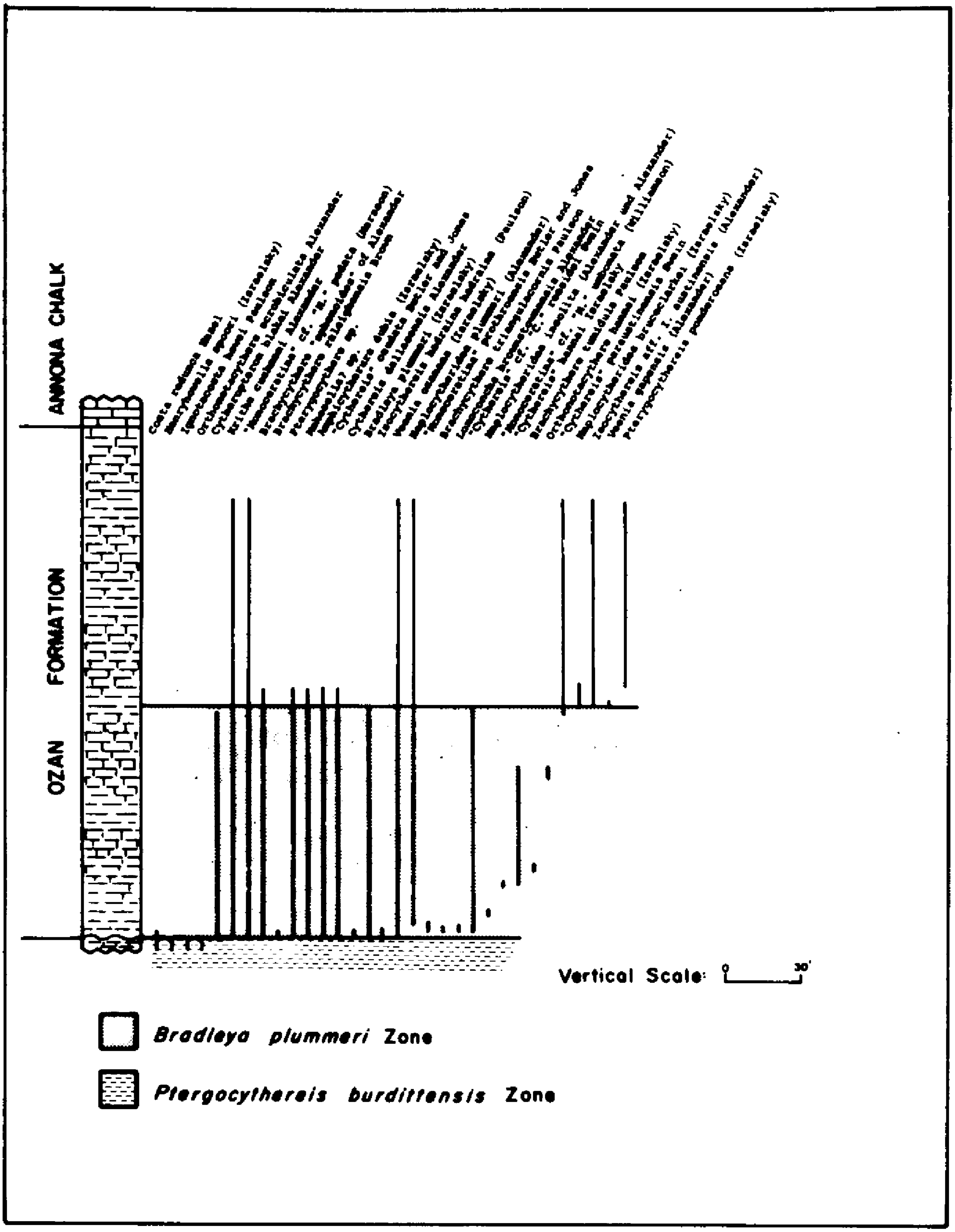
To the south in Ellis County the Austin-Taylor contact becomes erosional (Stephenson, 1937; Smith, 1955 ms) and can be traced into the area of maximum truncation at Waco. Paulson (1960 ms) believed the Austin-Taylor contact continues to be transitional in the area south of Dallas, appearing progressively lower in the section. However, this is in contrast to the findings of Smith (1955 ms) and the field observations of the writer.

At locality L, in northern Ellis County, samples were taken above and below the disconformity. Both the chalky beds below and marls above contain a typical Pterygocythereis burdittensis zone fauna.

In McLennan County at locality X (text fig. 5), in the area of maximum truncation of the Austin, there is a 90-foot section of Austin overlain disconformably by a few feet of blocky marl called "Lower Taylor" (Seewald, 1960, p. 51, 52). Samples from the chalk below the disconformity show that it is indeed, as Stephenson (1937) and Durham (1957 ms) demonstrated, early Austinian. A sample from above the disconformity yields a fauna that is, as Durham proposed, but contrary to Stephenson's thesis, late Austinian.

In Dallas, Ellis and McLennan Counties the lower part of the "Lower Taylor" is Austinian in age. However, Durham's proposal that the Austin-Taylor contact in these areas is correlative with the pre-Dessau-Dessau contact in central Texas must be modified. The Austin

Text-Fig. 8 -- Ranges of cytheracean ostracodes in western Little River County, Arkansas, and eastern McCurtain County, Oklahoma. Data from Collins (1960 ms) and Paulson (1960 ms, 1964).


ANNONA CHALK
OZAN FORMATION
Vertical Scale: 0 30'
Bradleya plummeri Zone
Ptergocythereis burditensis Zone

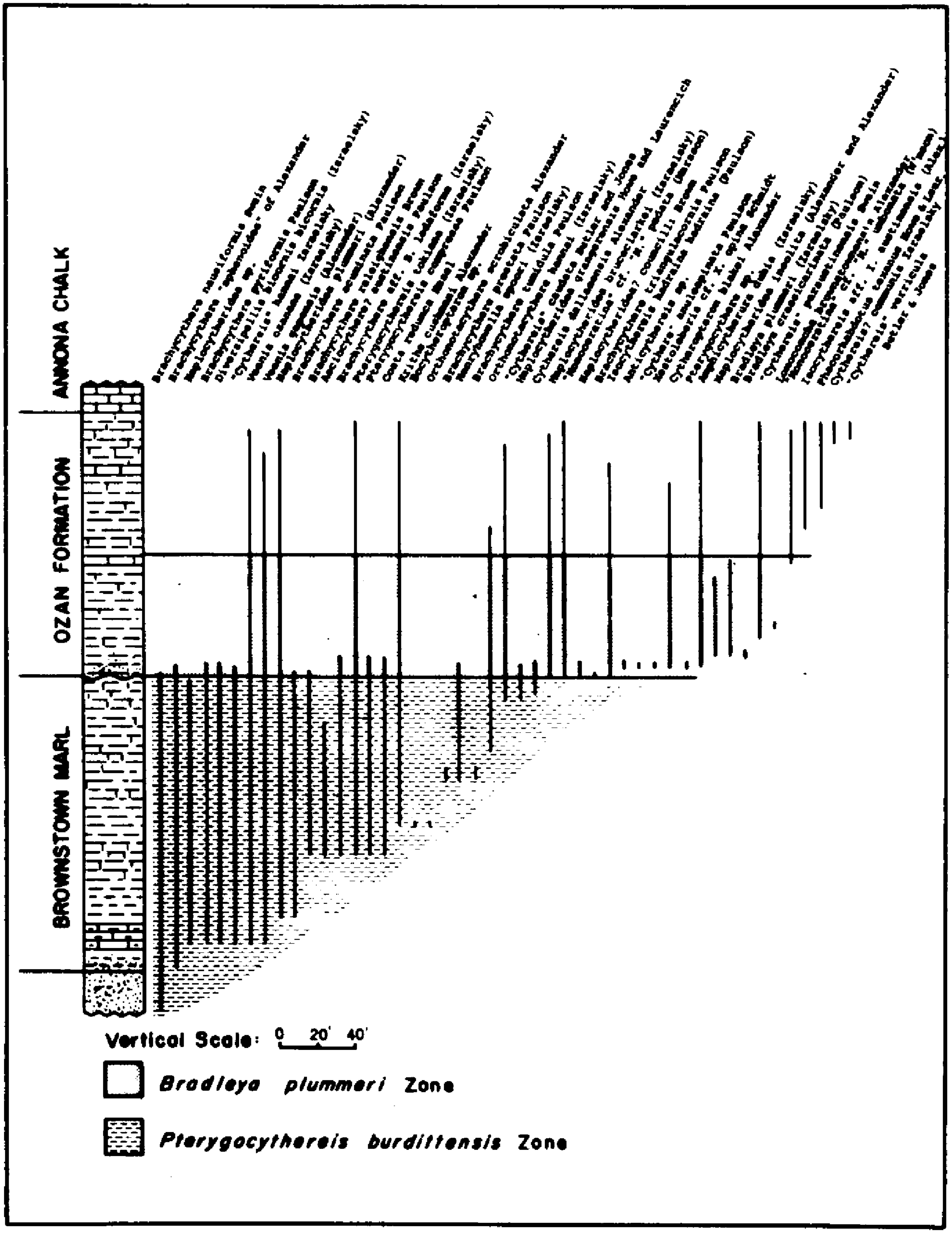
Text-Fig. 8

just below the disconformity in Ellis County and just below the transitional contact in Dallas County belongs to the Pterygocythereis burdittensis zone. Therefore, this portion of the section in these areas is not of pre-Dessau age as Durham proposed. In addition, the "Lower Taylor" just above the contact contains guide fossils of the Pterygocythereis burdittensis zone. Thus, since the base of the zone in Travis County is some 65 feet above the base of the Dessau, the disconformity in the north-central Texas area can hardly represent the same hiatus as that between the Dessau and lower Austin in central Texas. Nor can it represent the same hiatus as that between the Austin and Taylor as Stephenson thought. The disturbance which caused the removal of over 250 feet of section in the Waco area apparently was only local in nature.

Durham (1957 ms, p. 36) pointed out that the study of the Dessau between Temple and Waco is hampered because of faulting which dropped the upper Austin against the lower Austin. When informed of the results of this study, Durham (oral communication, 1963) suggested that a disturbed horizon he found in the upper Dessau in northern Bell County, just south of where the formation is faulted out, may represent the erosional surface in question. A discontinuity at this stratigraphic position would be consistent with the paleontologic data.

Data given by Paulson (1960 ms, 1964) allow tracing the Pterygocythereis burdittensis and Bradleya plummeri zones into northeast Texas (text fig. 7). Over the Preston Anticline the chalks of the Austin change to marls (Paulson, 1960 ms), but the biofacies remains nearly constant. The base of the Pterygocythereis burdittensis zone is at least as low as 40 feet above the top of the Blossom Sand, for Paulson (1960 ms) reports P. burdittensis from the Brownstown at this

Text-Fig. 9 -- Ranges of cytheracean ostracodes in the area of south-eastern Sevier County and northeastern Little River County, Arkansas. Data mainly from Collins (1960 ms) and Thorsen (1959 ms).



ANNONA CHALK
OZAN FORMATION
BROWNSTOWN MARL
Vertical Scale: 0 20' 40'
Bradleya plummeri Zone
Pterygocythereis burditensis Zone

Text-Fig. 9

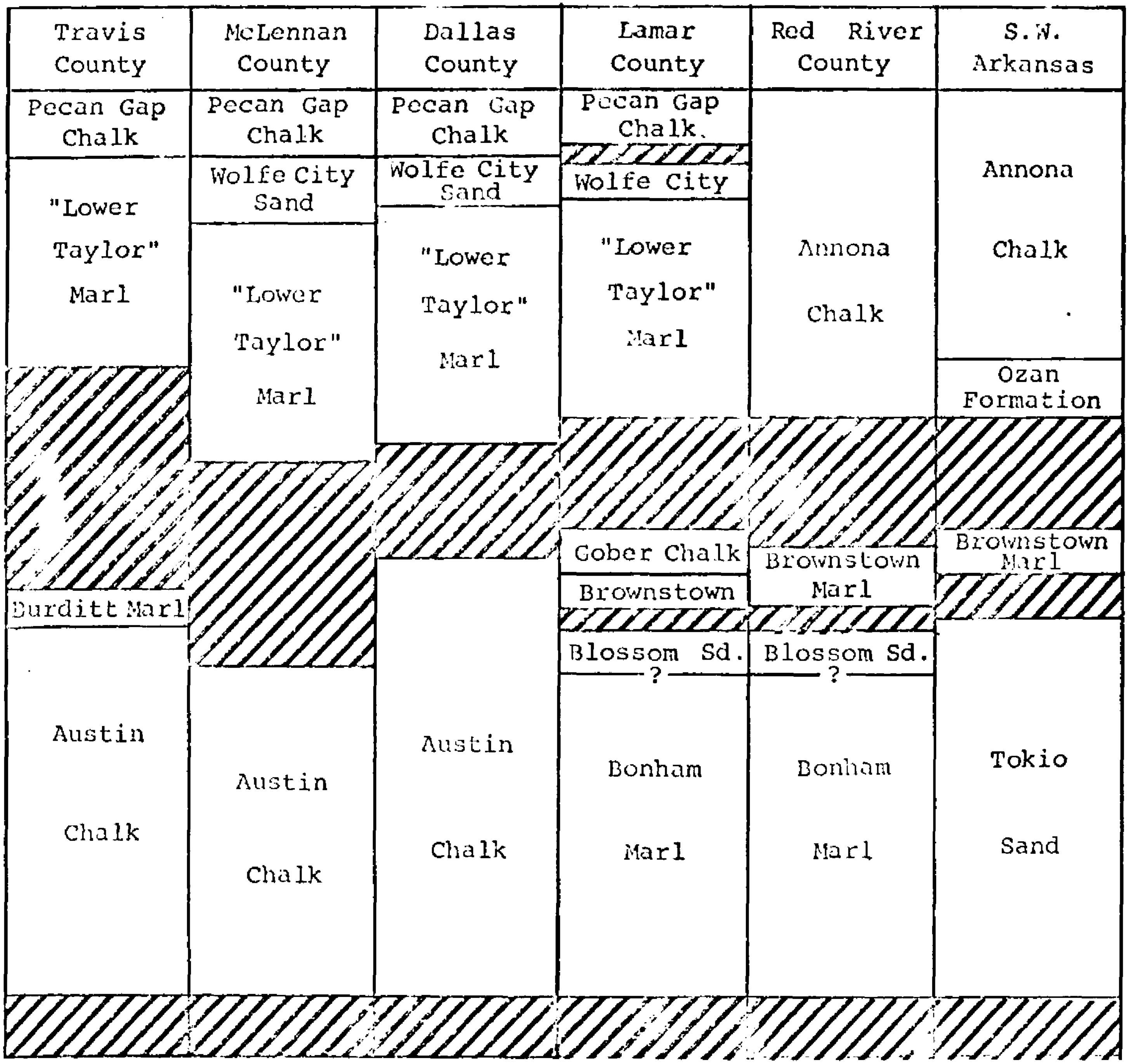
level in a well just south of Honey Grove, Fannin County.

The lowest in the northeast Texas section that Paulson (personal communication, 1963) found Bradleya plummeri was 150 feet above the "Lower Taylor"-Gober contact. This occurrence is in Fannin County near Ladonia, and the sample was taken one foot above the disconformity within the "Lower Taylor" (Paulson, 1960 ms). Thus the 150 feet of "Lower Taylor" below the disconformity, the Gober and the Brownstown are correlative with the lower 80 feet of "Lower Taylor" and the "Upper Chalk" at Dallas and with the Big House, Burditt and Dessau sequence in central Texas. The disconformity within the "Lower Taylor" in northeast Texas is temporally the same as that between the Big House and "Lower Taylor" in Travis County. These correlations essentially corroborate those of Paulson (1960 ms).

Data from Collins (1960 ms), Thorsen (1959 ms) and other sources permit the tracing of the Pterygocythereis burdittensis and Bradleya plummeri zones into Arkansas (text figs. 8, 9). The bulk of the Brownstown Marl of Arkansas falls within the Pterygocythereis burdittensis zone; however, the lower part as well as the underlying Tokio Sand is not very fossiliferous and the lower boundary could not be placed accurately. The base of the Bradleya plummeri zone falls at the disconformable Brownstown-Ozan contact, and the top of that zone is placed 100 feet above the base of the Ozan and approximately 150 feet below the Annona in western Little River County. In the area of northeastern Little River County the zonal boundary is 70 feet above the base and 80 feet below the Annona.

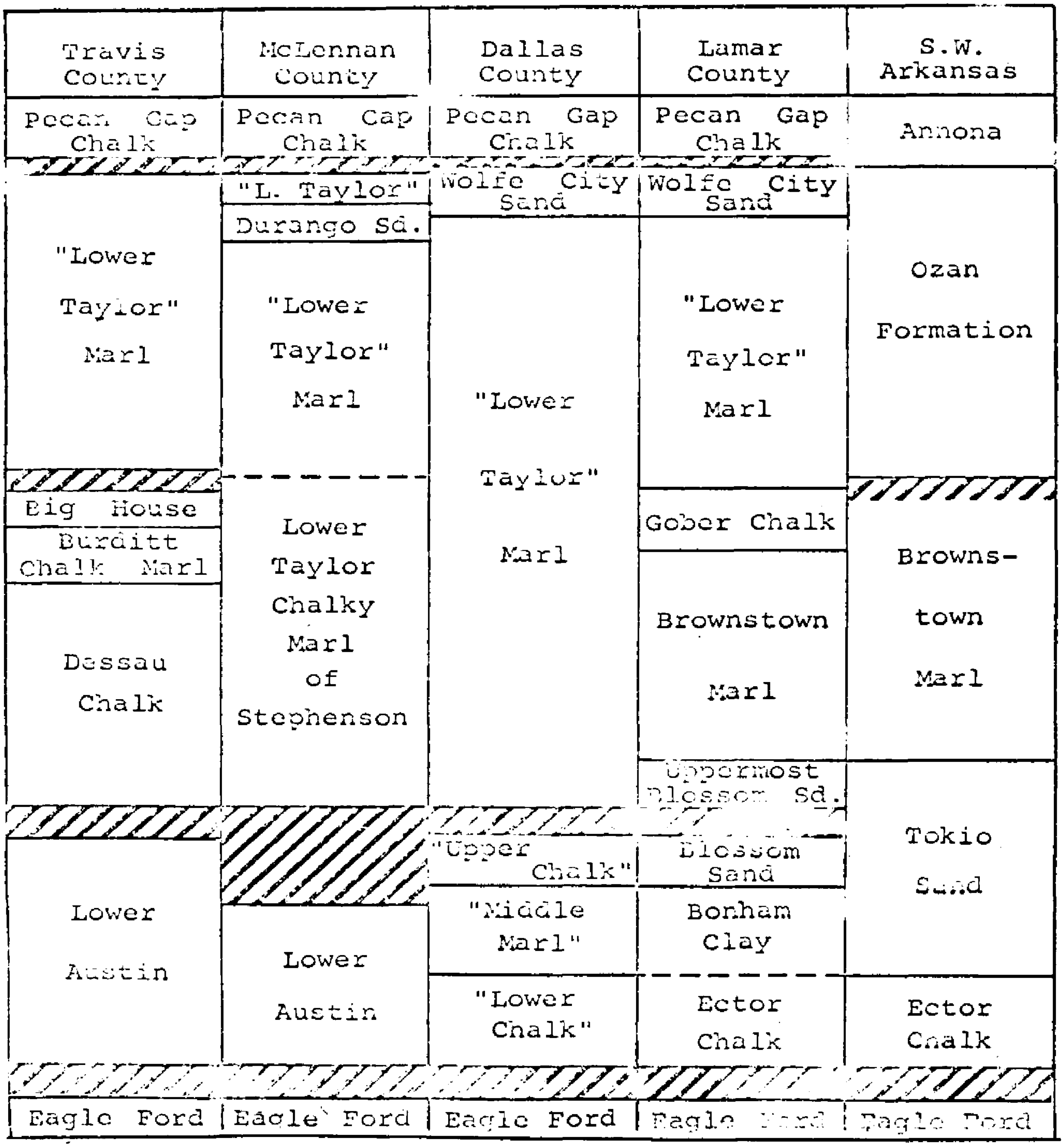
The paleontologic findings permit the correlation of the Brownstown of Arkansas with the lower part of the "Lower Taylor," the Gober

Text-Fig. 10 -- Correlation of the Austin Group and lower part of the Taylor Group as presented by Stephenson *et al*. (1942).


Travis County
McLennan County
Dallas County
Lamar County
Red River County
S.W. Arkansas
Pecan Gap Chalk
Pecan Gap Chalk
Pecan Gap Chalk
Pecan Gap Chalk.
"Lower Taylor" Marl
Wolfe City Sand
Wolfe City Sand
Wolfe City
Annona Chalk
"Lower Taylor" Marl
"Lower Taylor" Marl
"Lower Taylor" Marl
Annona Chalk
Ozan Formation
Gober Chalk
Brownstown Marl
Brownstown Marl
Burditt Marl
Brownstown
Blossom Sd.
Blossom Sd.
?
?
Austin Chalk
Austin Chalk
Austin Chalk
Bonham Marl
Bonham Marl
Tokio Sand

Text-Fig. 10

Text-Fig. 11 -- Correlation of the Austin Group and lower part of the Taylor Group as presented by Durham (1957 ms) and Murray (1961).


Travis County
Pecan Gap Chalk
"Lower Taylor" Marl
Big House
Burditt Chalk Marl
Dessau Chalk
Lower Austin
Eagle Ford
McLennan County
Pecan Cap Chalk
"L. Taylor"
Durango Sd.
"Lower Taylor" Marl
Lower Taylor Chalky Marl of Stephenson
Lower Austin
Eagle Ford
Dallas County
Pecan Gap Chalk
Wolfe City Sand
"Lower Taylor" Marl
"Upper Chalk"
"Middle Marl"
"Lower Chalk"
Eagle Ford
Lamar County
Pecan Gap Chalk
Wolfe City Sand
"Lower Taylor" Marl
Gober Chalk
Brownstown Marl
Uppermost Blossom Sd.
Blossom Sand
Bonham Clay
Ector Chalk
S.W. Arkansas
Annona
Ozan Formation
Browns-town Marl
Tokio Sand
Ector Chalk

Text-Fig. 11

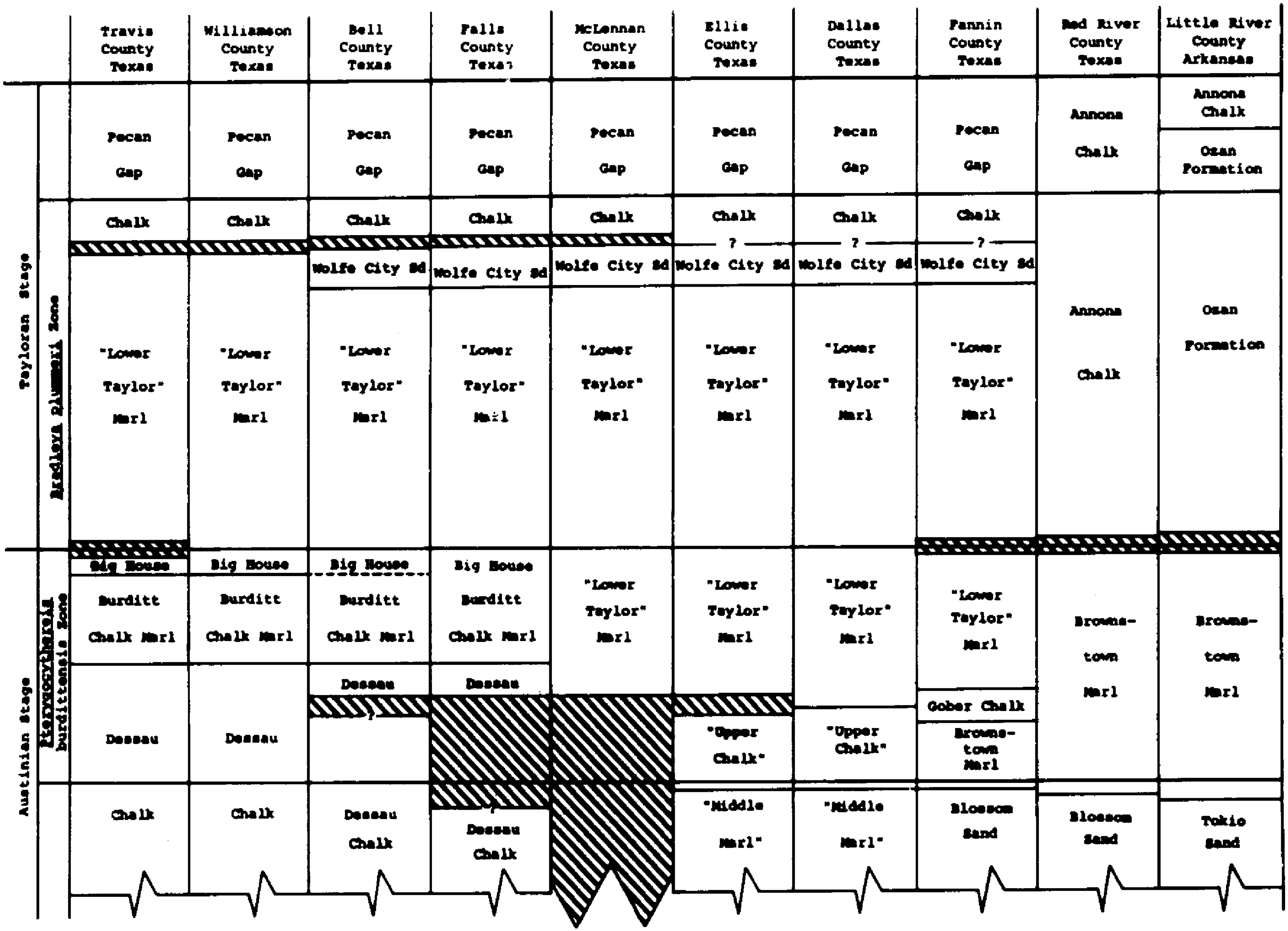
and the Brownstown of northeast Texas, with the lowermost "Lower Taylor" and the "Upper Chalk" at Dallas and with the Dessau, Burditt and Big House of central Texas. That portion of the Ozan which falls in the Bradleya plummeri zone is correlative with the lower Annona of Texas, the upper part of the "Lower Taylor," the Wolfe City and probably the lower portions of the Pecan Gap of northeast Texas and with the entire "Lower Taylor" and the lower part of the Pecan Gap of central Texas.

The zonation and concomitant correlation of these upper Austinian and lower Tayloran lithic units provides valuable information on sedimentary patterns and depositional history. While a detailed discussion is beyond the scope of this paper, a few general comments on the distribution of sediment types and their possible sources can be made.

Throughout the Austinian in central Texas chalky sediments were laid down (text fig. 14), while to the northeast in Arkansas and extreme northeast Texas arenaceous sediments predominated in the early Austinian (Tokio Sand) and argillaceous-calcareous sediments predominated in the late Austinian (Brownstown Marl). Between these two areas the sedimentaries were predominantly argillaceous-calcareous (Bonham Clay, Brownstown Marl) with incursions of sediment types more common in contiguous areas (Ector Chalk, Blossom Sand, Gober Chalk). The sources of clastics during the Austinian were apparently to the east, northeast and possibly the north, probably in the Ouachita and Arbuckle tectonic complexes.

The end of the Austinian in the area is evidenced by a faunal change and disconformities between the Austin and Taylor in central Texas, the Brownstown and Ozan in Arkansas and within the "Lower

Text-Fig. 12 -- Correlation of the Austin Group and lower part of the Taylor Group based on the biostratigraphic findings presented in this paper.


Travis County Texas
Williamson County Texas
Bell County Texas
Falls County Texas
McLennan County Texas
Ellis County Texas
Dallas County Texas
Fannin County Texas
Red River County Texas
Little River County Arkansas
Tayloran Stage
Bradleya plummeri Zone
Austinian Stage
Pterygocythereis burdittensis Zone
Pecan Gap
Chalk
Annona Chalk
Ozan Formation
Wolfe City Sd
"Lower Taylor" Marl
Annona Chalk
Big House
Burditt Chalk Marl
Dessau
Chalk
Dessau Chalk
Gober Chalk
Browns-town Marl
"Upper Chalk"
"Middle Marl"
Blossom Sand
Tokio Sand
?

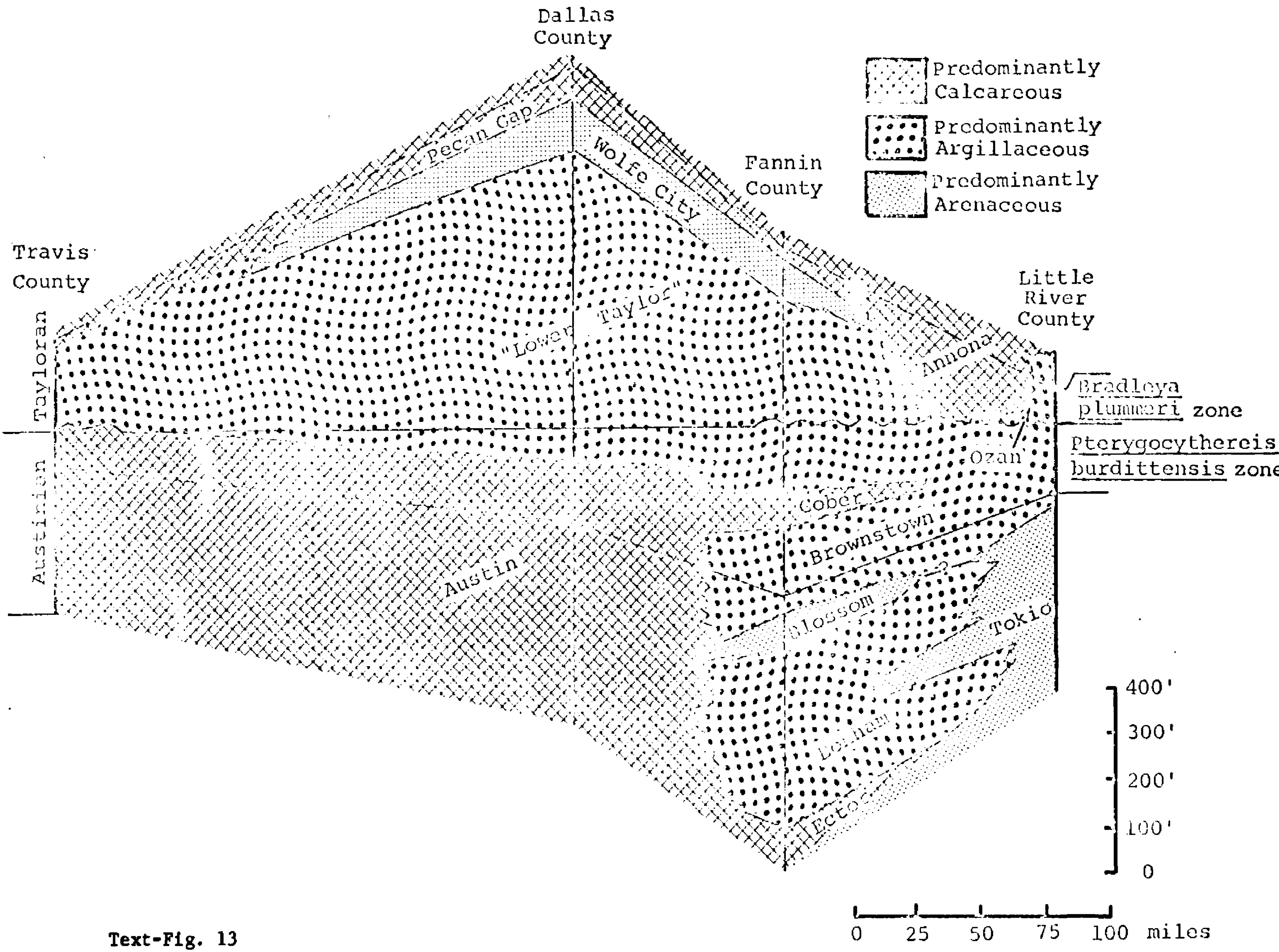
Text-Fig. 12

Taylor" in part of northeast Texas. The waters apparently receded from the shelf areas in the vicinity of the San Marcos Arch and in the Arkansas and extreme northeast Texas area while sedimentation continued between these two areas.

With the return of the seas a new sedimentary cycle began. During the time of deposition of the lower Tayloran, argillaceous sediments were laid down from central Texas into northeast Texas, while in extreme northeast Texas and Arkansas calcareous deposits (Annona Chalk of Texas, chalky horizons of the Ozan) were laid down. Calcareous deposition apparently spread over the basin later (Pecan Gap Chalk) after a northern incursion of arenaceous materials (Wolfe City Sand).

Thus, during the time of deposition of the _Bradleya plummeri_ zone, the sedimentary pattern was the reverse of that of the Austinian with calcareous sediments predominating in the northeast and argillaceous deposits to the southwest. The site of maximum deposition shifted southwestward to the Dallas area. The most important source of clastic materials seems to have been the Cordilleran Region with local positive areas, Wichita-Arbuckle and Ouachita complexes, playing a secondary role, e.g., in supplying clastic sediment for the Wolfe City Sand and marls of the Ozan.

Text-Fig. 13 -- Stratigraphic diagram showing the principal facies of the Austinian and lower Tayloran from central Texas to southwest Arkansas.


Dallas County
Fannin County
Travis County
Little River County
Predominantly Calcareous
Predominantly Argillaceous
Predominantly Arenaceous
Pecan Gap
Wolfe City
"Lower Taylor"
Annona
Bradleya plummeri zone
Pterygocythereis burdittensis zone
Ozan
Taylorian
Austinian
Austin
Gober
Brownstown
Blossom
Tokio
Ector
400'
300'
200'
100'
0
0 25 50 75 100 miles

Text-Fig. 13

LOCALITIES

A-1.--Dessau Chalk. Gully along west side of Dessau Road, 0.5 mile south of Braker Lane and 150 feet north of an east flowing tributary to Walnut Creek, northeast of Austin, Travis County, Texas. The sample was taken from a chalky marl bed. Collector: L. deA. Gimbrede

A-2.-- Dessau Chalk. Just north of A-1 approximately 20 feet higher in section. The sample was taken from a chalky marl. Collector: L. deA. Gimbrede

A-3.-- Dessau Chalk. Just north of A-2, but from gully on east side of road. The sample was taken from a soft, marly chalk just above a zone of abundant *Gryphaea aucella* and below a hard chalk ledge that causes a small waterfall. Collector: L. deA. Gimbrede

A-4.-- Dessau Chalk. Six feet above A-3. The sample was taken from a soft marl below a chalk bed which causes a small waterfall. The marl is very glauconitic and *Terebratulina* sp. occurs just above the chalk ledge. Collector: L. deA. Gimbrede

A-5.-- Dessau Chalk. Five feet above A-4. The sample was taken from a chalk bed which contains *Terebratulina* sp. Collector: L. deA. Gimbrede

A-6.-- Dessau Chalk. Ten feet above A-5. The sample was taken from a marly chalk which contains *Exogyra* aff. *E. ponderosa*. Collector: L. deA. Gimbrede

A-7.-- Dessau Chalk. Six feet above A-6. The sample was taken from a marl just below a chalk bed containing Exogyra laeviuscula. Collector: L. deA. Gimbrede

A-8.-- Dessau Chalk. First good exposure south of Braker Lane in ditch along east side of Dessau Road. The sample was taken from a soft, marly chalk with abundant Exogyra laeviuscula. Collector: L. deA. Gimbrede

B-1.-- Dessau Chalk. Second gully upstream from U. S. highway 290 crossing of Little Walnut Creek just northeast of Austin, Travis County, Texas. The sample was taken from a bored zone at the base of the section on the north (upthrown) side of a small fault. The bed is a fairly hard, white chalk with borings filled with the glauconitic marl from above. Collector: L. deA. Gimbrede

B-2.-- Dessau Chalk. Five feet above B-1. The sample was taken from a glauconitic marl. Collector: L. deA. Gimbrede

B-3.-- Dessau Chalk. Twelve feet above B-2. The sample was taken from a marl just below a hard chalk with Exogyra tigrina. Collector: L. deA. Gimbrede

B-4.-- Dessau Chalk. Same locality as B-1,2,3, but in first gully upstream. The sample was taken from a marl bed containing Exogyra laeviuscula just above gully bed. Collector: L. deA. Gimbrede

B-5.-- Dessau Chalk. Just above B-4. The sample was taken from a glauconitic marl just below a zone of borings at the base of the Burditt Chalk Marl. Collector: L. deA. Gimbrede

B-6.-- Burditt Chalk Marl. Just above B-5. The sample was taken from the lower three foot bed of glauconitic marl at the base of the Burditt. Collector: L. deA. Gimbrede

B-7.-- Burditt Chalk Marl. Twenty feet above B-6. The sample was taken from a marl bed which forms the brink of a small waterfall in the gully; the bed is eight feet above a biostrome of Ostrea centerensis. Collector: L. deA. Gimbrede

B-8.-- Burditt Chalk Marl. Two feet above B-6. The sample was taken from a marl bed with Exogyra aff. E. ponderosa and Parapuzosia sp. Collector: L. deA. Gimbrede

B-9.-- Big House Chalk. Same locality as above, but in third gully upstream. The sample was taken from a four-inch marl bed below a three-foot chalk bed 10 feet below the top of the Big House in the left bank of the gully. Collector: J. E. Hazel

B-10.-- Big House Chalk. Nine feet above B-9. The sample was taken from a marl below a one-foot chalk bed at the top of the Big House. Collector: J. E. Hazel

B-11.-- "Lower Taylor" Marl. Eleven feet above B-10, but in the right bank of the gully. The sample was taken from a dark brown, weathered marl. Collector: J. E. Hazel

C-1.-- Big House Chalk. Left bank of Little Walnut Creek 40 feet upstream from old Manor road crossing, Travis County, Texas, just northeast of Austin. The sample was taken from a six-inch marl bed above a two-foot chalk at the base of the section. Collector: L. C. Nichols

C-2.-- Big House Chalk. Left bank of Little Walnut Creek just north of first west-flowing tributary, 50 yards downstream from old Manor road crossing. The sample was taken from a soft marl six feet above the base of the outcrop and seven feet below the "Lower Taylor" contact. Collector: J. E. Hazel

C-3.-- Big House Chalk. Three feet above C-2. The sample was taken from a marl bed one foot thick just above a two-foot, knobby chalk. Collector: J. E. Hazel

C-4.-- Big House Chalk. Same locality, but 200 yards downstream. The sample was taken from the uppermost chalk bed. The bed is two feet thick and bored, the bore-holes filled with glauconitic marl. Collector: L. deA. Gimbrede

C-5.-- Big House Chalk. Same locality as C-2. The sample was taken from a marl at the top of the Big House. Collector: L. deA. Gimbrede

C-6.-- "Lower Taylor" Marl. Same locality as C-4. The sample was taken from a bed of yellow-brown clay with chalk pebbles just above the top of the Big House. Collector: L. deA. Gimbrede

C-7.-- "Lower Taylor" Marl. Same locality as C-2. The sample was taken from a yellow-brown, weathered clay six feet above the Big House and in the left bank of the small tributary just across from C-2. Collector: J. E. Hazel

C-8.-- "Lower Taylor" Marl.- Same locality, but 150 yards downstream. The sample was taken from the lowest bed of a bluff on the left bank of the stream 10 feet above water level. Collector L. deA. Gimbrede

C-9.-- "Lower Taylor" Marl.- Same locality as C-8. The sample was taken from a clay bed approximately seven feet above C-8. Collector: L. deA. Gimbrede

C-10.-- "Lower Taylor" Marl.- Same locality as C-8. The sample was taken from a clay bed at the top of the bluff. Collector: L. deA. Gimbrede

D-1.-- "Lower Taylor" Marl.- Just west of small roadside park on U. S. highway 290, 1.8 miles east of bridge over Little Walnut Creek, northeast of Austin, Travis County, Texas. The sample was taken from a marl a few feet lower than the base of Texas Bureau Economic Geology locality 226-T-50. Collector: L. deA. Gimbrede

D-2.-- "Lower Taylor" Marl.- Roadcut on U. S. highway 290, 0.1 mile east of Walnut Creek crossing and just west of MKT railroad crossing northeast of Austin, Travis County, Texas, (Texas Bureau locality 226-T-50). The sample was taken from an upper marly bed near the east end of the 20 foot exposure. Collector: L. deA. Gimbrede

D-3.-- "Lower Taylor" Marl.- One-half mile east of MKT railroad crossing of U. S. highway 290 northeast of Austin, Travis County, Texas. The sample was taken from the chalky clay beds in the upper part of a 12 foot exposure (Texas Bureau Economic Geology locality 226-T-40). Collector: L. deA. Gimbrede

D-4.-- "Lower Taylor" Marl. Same area as D-3, but 0.36 mile east of MKT railroad crossing. The sample was taken from clay-marl bed at the top of the "Lower Taylor." Collector: L. deA. Gimbrede

D-5.-- Pecan Gap Chalk. Same area as D-3, but 1.0 mile east of the MKT railroad crossing. The sample was taken from the basal Pecan Gap just above the "Lower Taylor" contact. Collector: L. deA. Gimbrede

E-1.-- Big House Chalk. Roadcut on county road uphill (west) of the road crossing of Walnut Creek, just west of Sprinkle Community northeast of Austin, Travis County, Texas. The sample was taken from a marl interbed at the base of the 17 foot exposure. Collector: J. E. Hazel

E-2.-- Big House Chalk. Five feet above E-1. The sample was taken from a two-foot marl bed. Collector: J. E. Hazel

E-3.-- Big House Chalk. Six feet above E-2. The sample was taken from a marl bed below the uppermost chalk at the exposure. Collector: J. E. Hazel

F-1.-- Burditt Chalk Marl. Right bank of Turnersville Creek 30 yards upstream from where the creek is crossed by a county road and 0.4 mile upstream from where Turnersville Creek flows into Onion Creek, southern Travis County, Texas. The sample was taken four feet above the base of the Burditt and just above an Ostrea centerensis biostrome. Collector: J. E. Hazel

G-1 to 10.-- Burditt-Big House chalky marl, "Lower Taylor" Marl and Wolfe City Sand (in this area called the Durango Sand) exposures in creek banks and roadside ditches in western Falls County (see text fig. 4). Collector: L. deA. Gimbrede

H-1.-- Big House Chalk. Chalk bluff on south side of San Gabriel River, one mile east of Jonah, Williamson County, Texas. The sample was taken from a marly chalk at the base of the bluff, 20 feet below the Austin-Taylor contact. Collector: L. deA. Gimbrede

H-2.-- Big House Chalk. Same locality as H-1. The sample was taken from a marly chalk two feet above H-1. Collector: L. deA. Gimbrede

H-3.-- Big House Chalk. Same locality as H-1. The sample was taken from the upper part of a massive chalk bed 14 feet above H-1. Collector: L. deA. Gimbrede

H-4.-- Big House Chalk. Same locality as H-1. The sample was taken from a chalky marl just below a one-foot chalk ledge at the top of the Big House. Collector: L. deA. Gimbrede

H-5.-- "Lower Taylor" Marl. Same locality as H-1. The sample was taken from a marly clay at the top of the bluff two feet above the Big House-"Lower Taylor" transitional contact. Collector: L. deA. Gimbrede

I-1.-- Pecan Gap Chalk. Just west of Taylor, Williamson County, Texas, in old brick pit just off old highway 43. This is locality 38 of Ellisor and Teagle (1934). Collector: D. E. Feray

J-1.-- Burditt Chalk Marl. Darrs Creek, 0.3 mile southeast of road crossing of northern branch of the stream, 1.5 miles west of Holland, Bell County, Texas, and 0.5 mile northeast of road crossing of southern branch of the stream. The sample was taken from a marl just above a chalk bed at water level which contains *Exogyra tigrina*. Collector: L. deA. Gimbrede

J-2.-- Burditt Chalk Marl. Same locality. The sample was taken from a marl five feet above J-2 and just above a bed with Parapuzosia sp. Collector: L. deA. Gimbrede

J-3.-- Burditt Chalk Marl. Same locality. The sample was taken from a nine-foot marl bed, which is the main marl in the bluff, 20 feet above J-1. Collector: L. deA. Gimbrede

J-4.-- Burditt Chalk Marl. Same locality. The sample was taken from a marl 32 feet above J-1. Collector: L. deA. Gimbrede

J-5.-- Burditt Chalk Marl. Same locality. The sample taken from the uppermost clay-marl in the bluff just above a hard, buff-colored ledge of calcarenite 45 feet above J-1. Collector: L. deA. Gimbrede

K-1.-- Big House Chalk. South Darrs Creek, 2.0 miles south of Holland, Bell County, Texas, 0.25 mile upstream from a county road crossing of the creek. The sample was taken from a marly chalk at the base of the section at the downstream end of first major meander. Collector: L. deA. Gimbrede

K-2.-- Big House Chalk. Same locality. The sample was taken from a marl four feet above K-1. Collector: L. deA. Gimbrede

K-3.-- Big House Chalk. Same locality, but at upstream end of bluff. The sample taken from a cream-colored marl 10 feet above K-1. Collector: L. deA. Gimbrede

K-4.-- "Lower Taylor" Marl. Same locality. The sample was taken from a marly clay at the top of the bluff, 15 feet above K-1. Collector: L. deA. Gimbrede

L-1.-- "Upper Chalk." Northern Ellis County, Texas, 1.2 miles southwest of Rockett just off state highway 813, 25 yards downstream from the crossing of a small tributary of Red Oak Creek. The sample was taken from a chalky marl four feet below the disconformable contact with the "Lower Taylor." Collector: J. E. Hazel

L-2.-- "Lower Taylor" Marl. Same locality. The sample was taken from dark, weathered marl two feet above the "Upper Chalk" contact. Collector: J. E. Hazel.

N-1.-- Just inside the eastern city limits of Rowlett, northeastern Dallas County, Texas, where the MKT railroad passes over state highway 7. The sample was taken from a weathered marl just north of the highway and just west of the overpass. Collector: J. E. Hazel

O-1.-- "Upper Chalk." Exposure 1.6 miles east of Garland, Texas, courthouse, fifty yards downstream from the crossing of a tributary of Rowlett Creek by state highway 7. The sample was taken from a blue, knobby marl below the uppermost chalk in the left bank. Collector: J. E. Hazel

O-2.-- "Lower Taylor" Marl. Same locality as O-1, but 20 yards downstream. The sample was taken from a clay marl just above a channeled horizon 10 feet above O-1. Collector: J. E. Hazel

P-1.-- "Upper Chalk." Holford Road crossing of Spring Creek in northern Dallas County, Texas. The sample was taken from a blue, knobby marl five feet northwest of the bridge in the right bank. Collector: J. E. Hazel

Q-1.-- "Upper Chalk." One mile southwest of Sachse, northern Dallas County, Texas, 500 yards southeast of the Brand Road-Rowlett Creek crossing, in a field where the chalk is exposed in the walls of an artificial farm pond. The sample was taken from a marl bed at the southeastern end of the pond six feet above water level. Collector: J. E. Hazel

R-1.-- "Upper Chalk." Halfway between the crossings of Apollo and Brand Roads by Spring Creek. The sample was taken from a soft marl in the right bank below a chalk with _Gryphaea aucella_ and large _Inoceramus_ sp. Collector: J. E. Hazel

S-1.-- "Upper Chalk." Just north of the Apollo Road crossing of Spring Creek in northern Dallas County, Texas. The sample was taken from a marl bed just above water level in the right bank. Collector: J. E. Hazel

T-1.-- "Middle Marl." S&S Aggregate Company quarry in southern Dallas County, Texas, 2.3 miles southeast of Loop 12-U.S. 75 and Interstate 45 intersection and 1000 yards west of the highway. The sample was taken from a marl bed with many large _Inoceramus_ sp. on the upper level of the quarry. Collector: J. E. Haz

T-2.-- "Middle Marl." Same locality as T-1. The sample was taken from a soft marl with abundant <u>Inoceramus</u> sp. 25 feet below T-1. Collector: J. E. Hazel

T-3.-- "Middle Marl." Roadcut on U. S. 75-Interstate 45 on south edge of Trinity River floodplain, 2.3 miles southeast of the Loop 12 intersection in southern Dallas County, Texas. The sample was taken from a chalky marl at the northwestern end of the outcrop six feet above road level. Collector: J. E. Hazel

U-1.-- "Middle Marl." East side of Lancaster Road, southern Dallas County, Texas, just north of Persimmon Road intersection and 4000 yards south of Loop 12 intersection. The sample was taken from a two-foot marl bed between thin chalks. Collector: J. E. Hazel

U-2.-- "Middle Marl." Same locality as U-1, but on the south side of Persimmon Road (uphill). The sample was taken from a four-foot marl bed below a five-foot chalk 30 feet above U-1. Collector: J. E. Hazel

V-1.-- "Upper Chalk." Southeastern Dallas, Texas, at the Elam Road bridge over Prairie Creek. The sample was taken from a chalky marl in the left bank 175 yards upstream from the bridge. Collector: J. E. Hazel

V-2.-- "Upper Chalk." Same locality as V-1, but 25 yards downstream from bridge. The sample was taken in a chalky marl bed four feet above water level in the right bank. Collector: J. E. Hazel

W-1.-- "Upper Chalk." Exposure 0.5 mile northwest of Wilmer, southern Dallas County, Texas, on left bank of Cottonwood Creek 25 yards east of old U. S. 75 crossing. The sample was taken from a marl eight feet above water level and below a two-foot chalk bed. Collector: J. E. Hazel

W-2.-- "Upper Chalk." Same locality as W-1. The sample was taken from a marl six feet below W-1. Collector: J. E. Hazel

X-1.-- Bruceville Chalk Marl. South bank of White Rock Creek halfway where it enters the Steinbeck Bend of the Brazos River and where it is crossed by farm road 1244 just north of Bellmead, McLennan County, Texas. The sample was taken from a marl fifty fee. above the base of the 90 foot exposure. Collector: L. deA. Gimbrede

X-2.-- Bruceville Chalk Marl. Same locality. The sample was taken from a marl below a five-foot chalk 20 feet above X-1. Collector: L. deA. Gimbrede

X-3.-- Bruceville Chalk Marl. Same locality. The sample was taken from a marl three feet below the disconformable contact with the "Lower Taylor." Collector: L. deA. Gimbrede

X-4.-- "Lower Taylor" Marl. Same locality. The sample was taken from a brown, blocky marl two feet above the disconformable contact with the Bruceville. Collector: J. E. Hazel

Y-1.-- "Lower Taylor" Marl. Left bank of the Brazos River 1.0 mile south-southeast of Lake Creek Reservoir McLennan County, Texas. The sample was taken from a blue, somewhat fissle marl three feet above water level. Collector: J. E. Hazel

Y-2.-- "Lower Taylor" Marl. Same locality. The sample was taken 14 feet above Y-1. Collector: J. E. Hazel

Z-1.-- Pecan Gap Chalk. Two miles southeast of Perry, Falls County, Texas, left bank of Big Sandy Creek 1.0 mile north of intersection of farm road 2307 and state road 6. The sample was taken from a soft, yellow marl below a chalky bed five feet above the base of the Pecan Gap. Collector: J. E. Hazel

2A-1.-- "Lower Taylor" Marl. Gully 100 yards east of state highway 24, 0.9 mile north of Lake Creek, Delta County, Texas. The sample was taken near the crest of the hill. Collector: L. G. Nichols

2B-1.-- Buckrange Sand member of Ozan Formation. NE$\frac{1}{4}$, NW$\frac{1}{4}$, Sec. 10, T11S, R29W, Sevier County, Arkansas, southwestern end of Ozan outlier on Brownstown-Ben Lomond road. This is stop 3 (pp. 209-211) of Shreveport Geol. Soc 14th Annual Field Trip (1939). Collector: B. C. Craft

2C-1.-- Brownstown Marl. NE$\frac{1}{4}$, NW$\frac{1}{4}$, NW$\frac{1}{4}$, Sec. 10, T11S, R29W, Sevier County, Arkansas, roadcut on south side of Ben Lomond-Brownstown road, 0.1 mile west of Gravelly Hill Church. Collector: B. C. Craft

2D-1.-- Brownstown Marl. Center, NW$\frac{1}{4}$, Sec. 5, T11S, R29W, 0.5 mile east of Wilson Creek on road to Ben Lomond from U. S. 71, Sevier County, Arkansas. Collector: H. V. Howe

2E-1.-- Brownstown Marl. SW$\frac{1}{4}$, SE$\frac{1}{4}$, Sec. 5, T11S, R29W, ditch on north side of road, 0.5 mile south of Ben Lomond, Sevier County, Arkansas. This is stop 2 (p. 209) of Shreveport Geol. Soc. 14th Annual Field Trip (1939). Collector: B. C. Craft

2G-1.-- Brownstown Marl. Roadside gully 1.35 miles northwest of Brownstown, Sevier County, Arkansas. Collector: H. V. Howe

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PLATE I

Some diagnostic Austinian species.

1 <u>Veenia bonhamensis</u> Paulson X 50

Exterior of right valve of a male. Specimen from the lower Austin in Travis County, Texas.

2 <u>Brachycythere triangulacornis</u> Paulson X 50

Exterior of right valve. Specimen from the Big House Chalk in Travis County, Texas (sample C-2).

3 <u>Phacorhabdotus simplex</u> Paulson X 50

Exterior of left valve. Specimen from the "Middle Marl" in Dallas County, Texas (sample T-1).

4 <u>Cytheropteron glawei</u> Paulson X 80

Exterior of left valve. Specimen from the Burditt Chalk Marl in Travis County, Texas (sample B-6).

5 <u>Diversipellis bicornis rectangula</u> Hazel X 50

Exterior of left valve. Specimen from the lower Austin in Travis County, Texas.

6 <u>Isocythereis austinensis</u> (Alexander) X 50

Exterior of left valve. Specimen from the "Middle Marl" in Dallas County, Texas (sample T-3).

7 <u>Trachyleberidea anocula</u> (Paulson) X 50

Exterior of left valve. Specimen from the "Upper Chalk" in Dallas County, Texas (sample W-1).

8 <u>Diversipellis alexanderi</u> (Morrow) X 50

Exterior of left valve. Specimen from the Big House Chalk in Travis County, Texas (sample C-2).

9 *Diversipellis niobrarensis* (Morrow) X 50

Exterior of left valve. Specimen from the "Upper Chalk" in Dallas County, Texas (sample O-1).

10 *Diversipellis bicornis bicornis* (Israelsky) X 50

Exterior of left valve. Specimen from the Big House Chalk in Travis County, Texas (sample E-1).

11 *Brachycythere* aff. *B.* "*sphenoides*" of Alexander X 50

Exterior of left valve. Specimen from the lower Austin in Travis County. This undescribed species is rather common in the lower Austin and ranges into the upper Austin.

12 *Brachycythere nausiformis* Swain X 50

Right exterior view of a carapace. Specimen from the Tokio Sand in Sevier County, Arkansas.

13 *Pterygocythereis burdittensis* (Paulson) X 50

Exterior of left valve. Specimen from the Big House Chalk in Travis County, Texas (sample C-2).

14 *Brachycythere acuminata* Paulson X 50

Exterior of left valve. Specimen from the Big House Chalk in Travis County, Texas (sample C-2).

15 *Pterygocythereis ingens* Hazel X 50

Exterior of right valve. Specimen from the Big House Chalk in Williamson County, Texas (sample H-1).

16 *Isocythereis hadraina orchama* Hazel X 50

Exterior of left valve. Specimen from the "Middle Marl" in Dallas County, Texas (sample T-3).

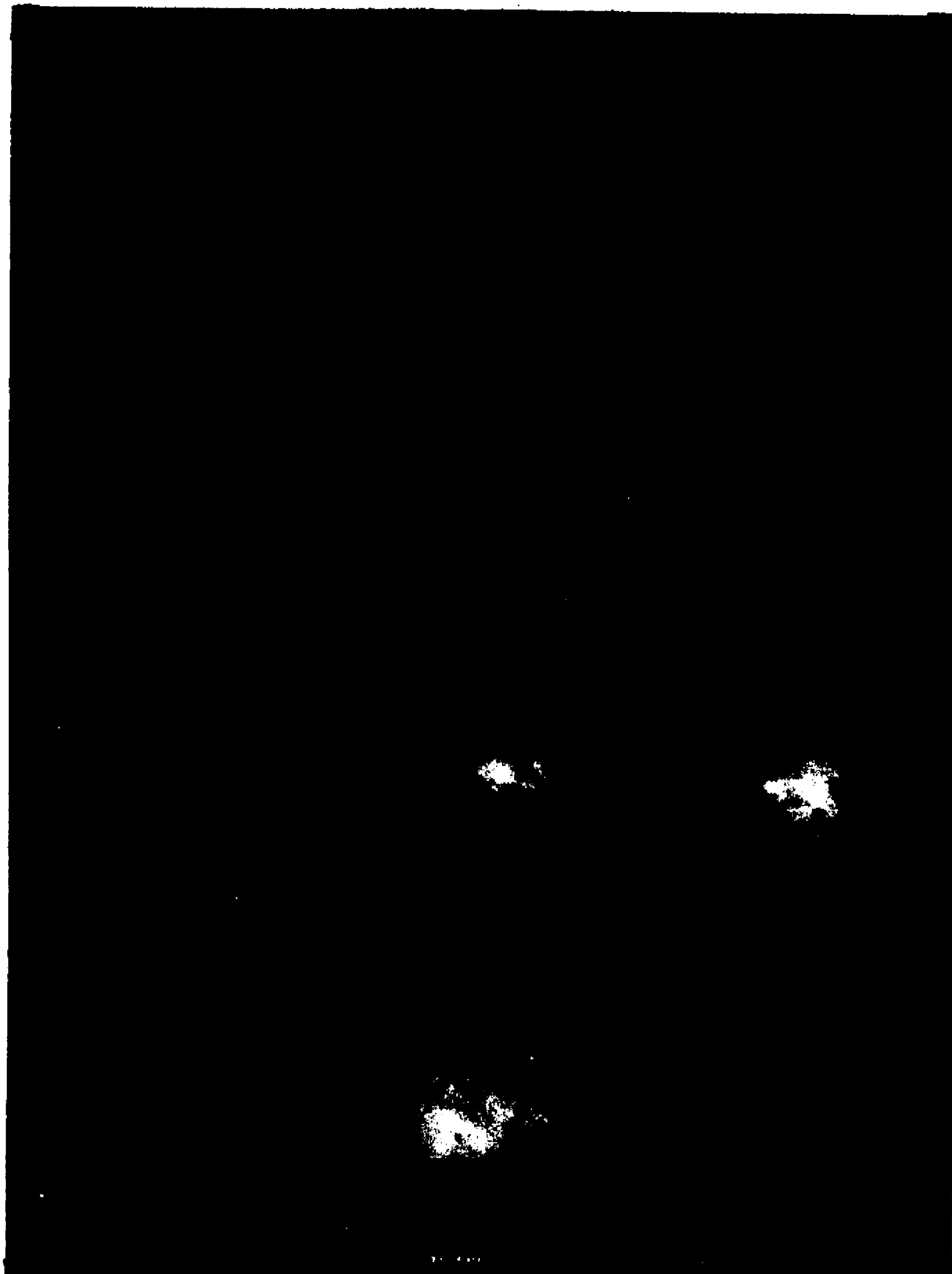

Plate I

PLATE II

Some species common in the upper Austinian

and/or lower Tayloran

1 Pterygocythereis compressa (Paulson) X 50

Exterior of left valve. Specimen from the Brownstown Marl in Sevier County, Arkansas (sample 2E-1).

2 "Cythereis" hannai Israelsky X 50

Exterior of left valve. Specimen from the Brownstown Marl in Sevier County, Arkansas (sample 2D-1).

3 "Cythereis" caudata Butler and Jones X 50

Exterior of left valve. Specimen from the "Upper Chalk" in Dallas County, Texas (sample P-1).

4 Henryhowella spoori (Israelsky) X 50

Exterior of right valve. Specimen from the Durango Sand in Falls County, Texas (sample G-8).

5 Cytheropteron furcalatum Alexander X 50

Exterior of left valve. Specimen from the Big House Chalk in Williamson County, Texas (sample H-1).

6 Costa redunca Hazel X 50

Exterior of right valve. Specimen from the Buckrange Sand Member of the Ozan Formation in Sevier County, Arkansas (sample 2B-1).

7 Loxoconcha Brownstownensis Alexander X 80

Exterior of left valve. Specimen from the "Lower Taylor" Marl in Travis County, Texas (sample D-3).

8 Brachycythere pyriformis Paulson X 50

Exterior of left valve. Specimen from the "Upper Chalk" in Dallas

County, Texas (sample W-1).

9 <u>Isocythereis</u> <u>hadraina</u> <u>hadraina</u> (Paulson) X 50

Exterior of left valve. Specimen from the Big House Chalk in Travis County, Texas (sample B-10).

10 <u>Cythereis</u> <u>dallasensis</u> Alexander X 50

Exterior of right valve. Specimen from the Big House Chalk in Travis County, Texas (sample C-1).

11 <u>Brachycythere</u> <u>raleighensis</u> Brown X 50

Right exterior view of carapace. Specimen from the Brownstown Marl in Sevier County, Arkansas (sample 2E-1).

12 <u>Veenia</u> <u>ozanana</u> (Israelsky) X 50

Exterior of left valve. Specimen from the "Upper Chalk" in Dallas County, Texas (sample R-1).

13 "<u>Cythere</u>" <u>anulospinata</u> Paulson X 80

Exterior of left valve. Specimen from the "Upper Chalk" in Dallas County, Texas (sample R-1).

14 <u>Pterygocythereis</u> <u>tokiana</u> (Israelsky) X 50

Exterior of left valve. Specimen from the Big House Chalk in Travis County, Texas (sample C-2).

15 <u>Brachycythere</u> "<u>sphenoides</u>" of Alexander X 50

Exterior of left valve. Specimen from the Big House Chalk in Travis County, Texas (sample C-2).

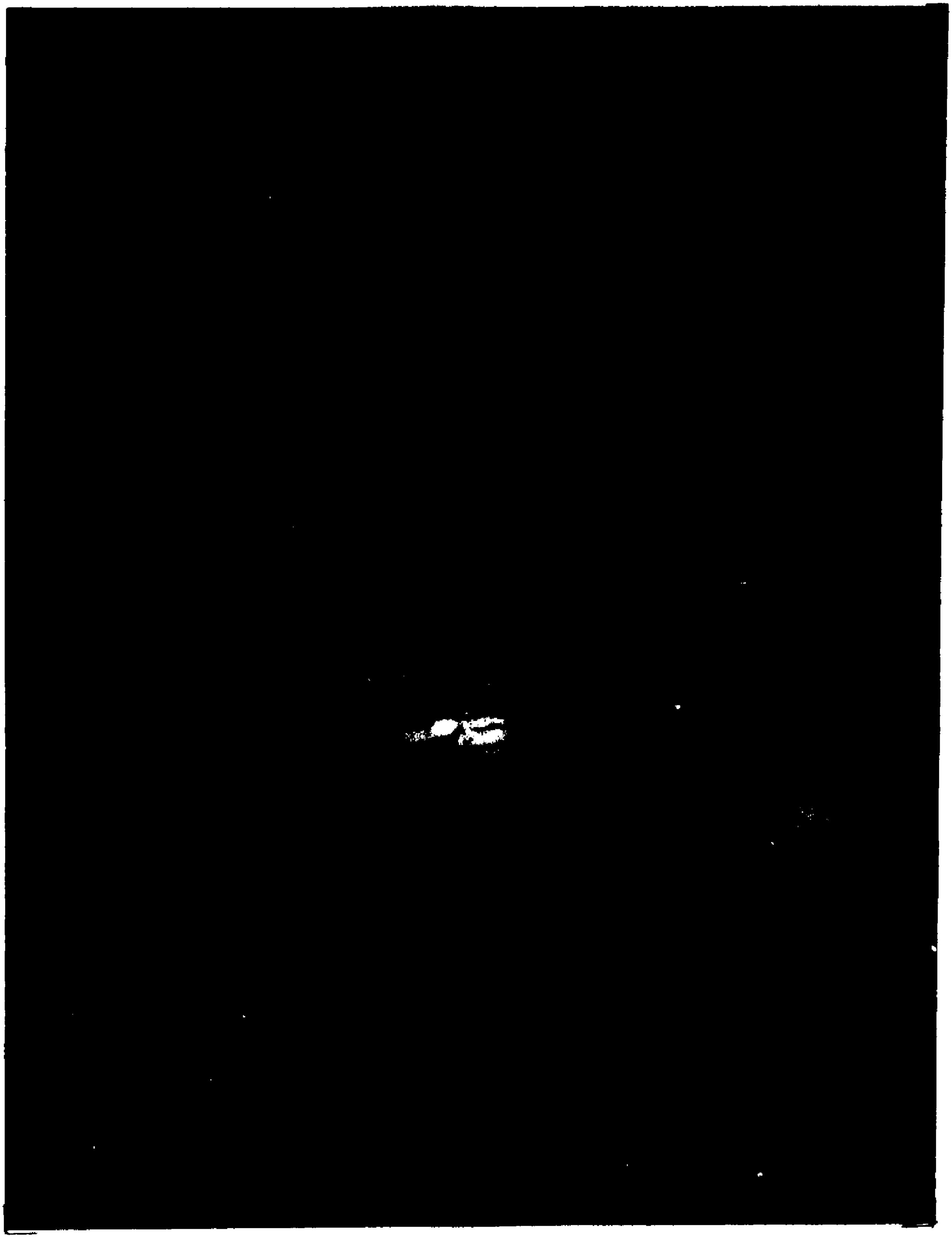

Plate II

PLATE III

Some diagnostic Tayloran species.

1 *Haplocytheridea grangerensis* Howe and Laurencich X 50

Exterior of left valve. Specimen from the Big House Chalk in Travis County, Texas (sample C-2). This species is more common in the Austinian.

2 *Haplocytheridea plummeri* (Alexander) X 30

Right exterior of carapace. Specimen from the "Lower Taylor" Marl in Travis County, Texas (sample (D-3).

3 *Cytheropteron blakei* Alexander X 50

Exterior of right valve. Specimen from the Ozan Formation in Howard County, Arkansas.

4 *Orthonotacythere hannai* (Israelsky) X 50

Exterior of left valve. Specimen from the "Lower Taylor" Marl in Travis County, Texas (sample D-4).

5 *Haplocytheridea? councilli* Brown X 50

Exterior of right valve. Specimen from the Buckrange Sand Member of the Ozan Formation in Sevier County, Arkansas (sample 2B-1).

6 *Amphicytherura dubia* (Israelsky) X 80

Exterior of right valve. Specimen from the Big House Chalk in Travis County, Texas (sample C-1).

7 *Ignotacosta howei* Paulson X 80

Exterior of left valve. Specimen from the "Lower Taylor" Marl in Falls County, Texas (sample G-10).

8 *Veenia gapensis* (Alexander) X 50

Exterior of right valve. Specimen from the "Lower Taylor" Marl in Falls County, Texas (sample G-10).

9 Diversipellis taylorensis (Paulson) X 50

Exterior of left valve. Specimen from the "Lower Taylor" Marl in Travis County, Texas (sample D-2).

10 Isocythereis aff. I. austinensis (Alexander) X 50

Exterior of left valve. Specimen from the "Lower Taylor" Marl in Delta County, Texas (sample 2A-1). This species is more common in the zone above the Bradleya plummeri zone.

11 Bradleya crassicarinata (Paulson) X 50

Exterior of left valve. Specimen from the "Lower Taylor" Marl in Travis County, Texas (sample D-1).

12 Brachycythere tumidula Paulson X 50

Exterior of left valve. Specimen from the "Lower Taylor" Marl in in Travis County, Texas (sample C-9).

13 Bradleya plummeri (Israelsky) X 50

Exterior of right valve. Specimen from the "Lower Taylor" Marl in Travis County, Texas (sample C-9).

14 Haplocytheridea insolita (Alexander and Alexander) X 50

Left exterior of carapace. Specimen from the "Lower Taylor" Marl in Falls County, Texas (sample G-10).

15 Bradleya plummeri (Israelsky) X 50

Exterior of an abraded left valve. Specimen from the Durango Sand in Falls County, Texas (sample G-9).

16 Bradleya rugosissima (Alexander) X 50

Exterior of left valve. Specimen from the "Lower Taylor" Marl in Travis County, Texas (sample C-7).

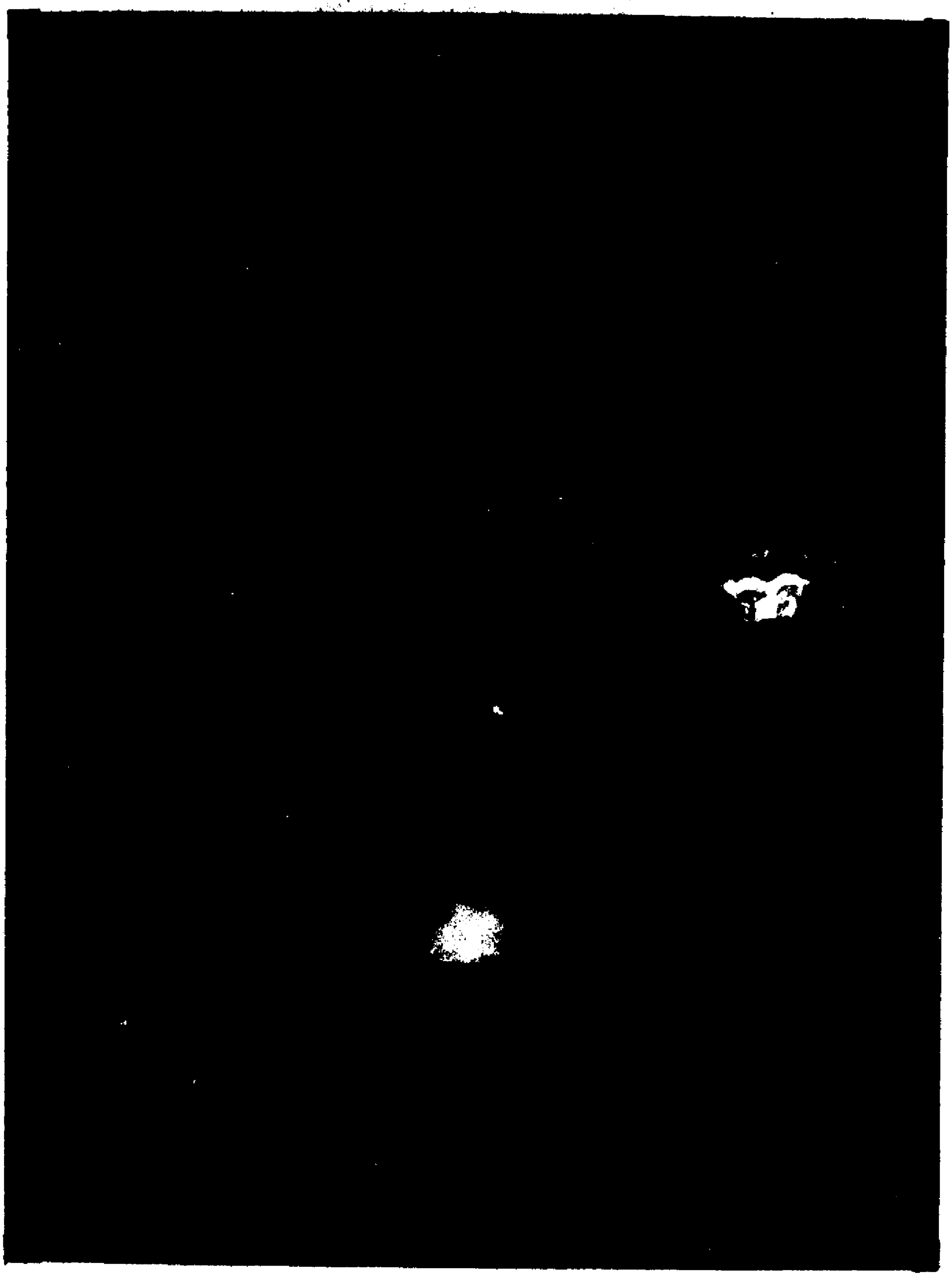

Plate III

VITA

Joseph Ernest Hazel was born in Caruthersville, Missouri, on July 7, 1933, the son Ernest and Irene Hazel. He attended the Caruthersville public schools and graduated from high school in 1951. He received an A.B. degree from the University of Missouri in January of 1956. After serving over two years in the United States Army as an artillery officer, he returned to the University of Missouri and in June of 1960 he received the M.A. degree. In September of 1960 he entered Louisiana State University as a candidate for the Ph.D. degree, graduating in June 1963.

EXAMINATION AND THESIS REPORT

Candidate: Joseph Ernest Hazel

Major Field: Geology

Title of Thesis: Part I. Systematics of some Gulfian Trachyleberiids from Texas and Arkan
Part II. Ostracode Biostratigraphy in some Austinian-Tayloran Rocks.

Approved:

Alan H. Cheetham

Major Professor and Chairman

Max Goodrich

Dean of the Graduate School

EXAMINING COMMITTEE:

C. O. Durham Jr.

A. E. Sandberg

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Date of Examination:

April 19, 1963